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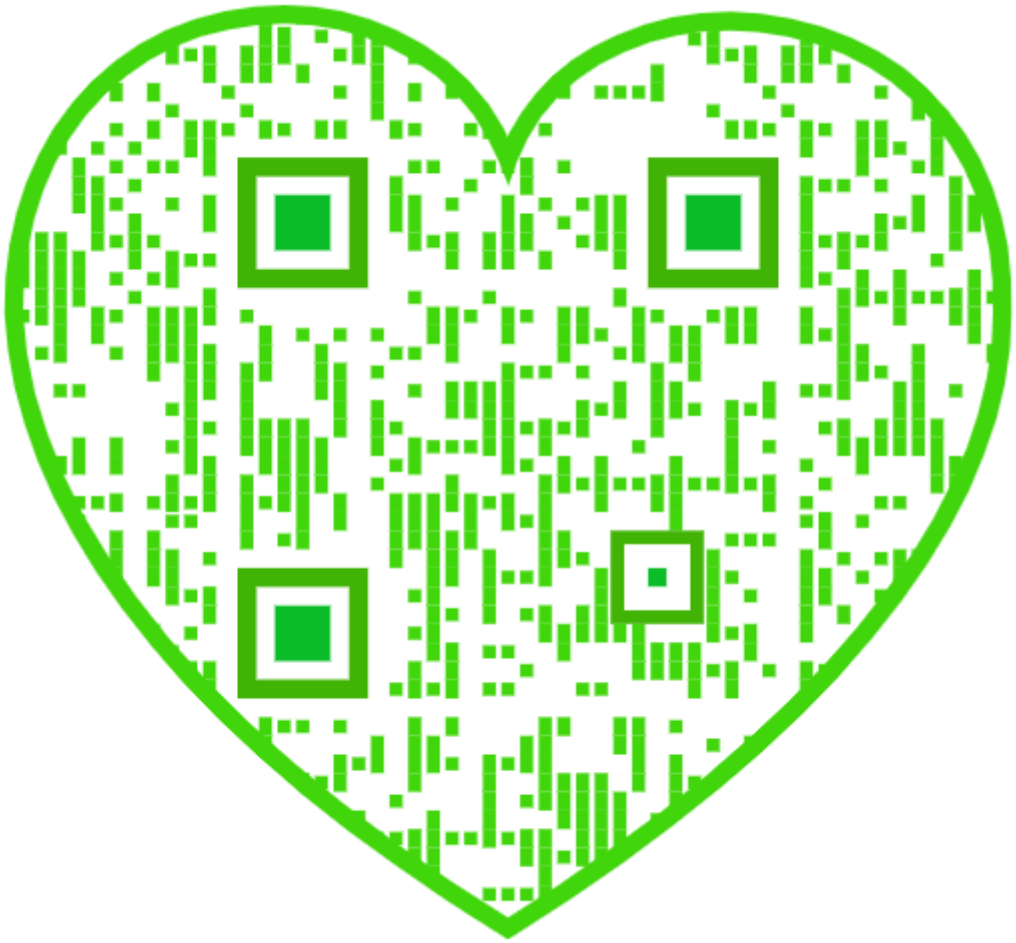

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ATLAS FOR ELECTRO-DIAGNOSIS AND THERAPEUTICS

ATLAS FOR ELECTRO-DIAGNOSIS AND THERAPEUTICS

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1920

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To the memory of Professor THÉODORE GUILLOZ, *of Nancy, who died during the war, a victim to science, my friend and instructor in medical electricity, I dedicate this little book, in which he had wished to collaborate.*

I beg Professor A. NICOLAS *also to accept the homage of it in remembrance of the cordial welcome I received in his laboratory at Nancy,* 1905–1906, *when studying for the certificate in advanced anatomy.*

I submit it, lastly, to my colleagues in physiotherapy, French and Allied, whose task continues to grow in importance, and who all devote themselves so ardently to-day to the noble duty of human reparation.

F. MIRAMOND DE LAROQUETTE.

FOREWORD

THE English reading people owe this volume to Miss Mary Cheetham, who has placed a rendering of the original text at their disposal.

The author has given great care and the fruits of a large experience to the compilation of this book. The practitioner who is engaged in diagnostic and therapeutic work will find within its pages a great deal of valuable information. The text is concise and practical, offering many opportunities for refreshing the memory on important anatomical and histological points which are so essential in dealing with practical details in routine work. It should be of great value to the practitioner who proposes to submit himself for examination in Radiology and Electrology.

The translation into English of a work by a distinguished French author is, we trust, an indication of the closer rapprochement in scientific circles which may be not the least important result of the recent co-operation of the two countries in the field.

It is with profound regret that we learn of the sudden death of Miss Cheetham on the eve of publication of this book. It is difficult to speak too highly of the translation: the language is clear, terse, and concise; the style is easy, and the book reads as if it had been written in English and not merely translated. It is a matter for real regret that such a sympathetic co-worker is lost to the scientific world.

ROBERT KNOX.

38, HARLEY STREET, W.,
February, 1920.

AUTHOR'S PREFACE TO ENGLISH EDITION

APRÈS s'être dévouée de longs mois dans les formations sanitaires françaises, et y avoir mérité les plus émouvants témoignages de gratitude, Miss Mary Cheetham a voulu au lendemain de la guerre être encore utile aux malades et aux blessés.

C'est dans cette pensée qu'elle a consenti de traduire mon "Atlas d'Electrodiagnostic et de Physiothérapie" qu'elle avait eu entre les mains dans un hôpital de France. Je lui reste fort reconnaissant et je souhaite de tout cœur que l'ouvrage si heureusement traduit par elle et confié aux grands editeurs, Baillière, Tindall et Cox de Londres, rende service aux glorieux blessés des armées et da la marine anglaises.

Le Docteur Knox de Londres, les Professeurs Waterston de St. Andrews, et Bryce de Glasgow ont bien voulu s'intéresser à ce travail: je les prie de trouver ici l'expression de mes sincères remerciements.

J'adresse à ma traductrice, Miss Mary Cheetham, l'hommage d'une respectueuse gratitude.

MIRAMOND DE LAROQUETTE.

ALGER,
décembre 20, 1919.

INTRODUCTION

THE examination of the electric reactions of the organs of the peripheral motor nerve system is a precise method of diagnosis, of which the utility is greater than ever to-day, and the need more frequent, on account of the many therapeutic and medico-legal problems to which the wounds of war give rise.

Every wound, every serious traumatism, involves, indeed, even without grave injury to the nerve trunks, modifications more or less marked, quantitative or qualitative, of the electric response of the nerves and muscles. The measure of these modifications reveals better, perhaps, than any other procedure the degree of injury or the integrity of organs. It is indicated for the majority of wounds in battle or in civil life, as much for the direction of treatment as for the estimation of impairment.

There are very many doctors even in normal times, and still more at the present moment, who have to practise or to interpret this kind of examination, for which a precise knowledge of the anatomical elements in question is above all necessary. The author and the editor believe they are doing good service to-day* in placing at their disposal this atlas-manual, in which are presented, in such a way as to be seen at a rapid glance, the normal anatomical data that we ought to have well in our mind in order to conduct an electro-diagnosis, or to draw our conclusions from it. The anatomical plates which constitute the chief feature of the book have been drawn partly after the works of Cruveilhier, Ranvier, Testut, Poirier, Nicolas and Paul Richer, and partly after radiographs taken from the living; and the very brief text has been

* The greater part of this book was arranged, or designed, in 1913 and 1914; but the circumstances of the war and the fulfilment of more urgent duties have delayed the publication of it until now.

arranged in such a way as to give prominence to the organs particularly important from our point of view—*e.g.*, nerve tracts, plexuses, and superficial nerves and muscles, with their motor points.

To the anatomical data we have added, with the necessary technical explanations, tables of normal coefficients of the electric response of nerves and muscles, which we have proved, after a very numerous series of examinations of subjects, either sound or affected by unilateral lesions, and which may be of use as terms of comparison in the analysis of pathological cases.

The anatomical data which are indispensable for electro-diagnosis are equally so for the direction of the various physio-therapeutic remedies on which depends recovery from all nervous and muscular weakness, and from the majority of wounds caused by war, in the workshop, and otherwise.

Whether it is a question of electricity, heat, light, X rays, movement, or massage, the physio-therapeutic methods, which have emerged from the empirical stage, demand a precise knowledge of the organs to which they are directed, in order that they may be correctly applied.

The physio-therapeutic doctor will here find briefly summed up and arranged in a convenient way the most useful anatomical data on nerves, muscles, and joints.

The last mentioned are considered here particularly from a mechanical point of view, with the muscles which act upon them, and which constitute their real ligaments, and the normal amplitude of the principal movements of which they are the seat.

The angular measure of these movements may serve as a basis for the estimation of functional weakness, whether nervous, muscular, or articular, as well as in the manual or mechano-therapeutic exercise of the different segments of the limb.

The work ends with a summary of the anatomical constitution of the skin and its highly important rôle in physio-therapy.

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I.—SENSORY MOTOR NERVE PATHS.

Neurons, peripheral and central—Conductors, peripheral nerves, plexuses, spinal roots, white matter of spinal cord and encephalon—Explanation of phenomena, anæsthesia, paralysis, sleep, memory.

Reflex Paths : Stimuli—Ganglionic cells—Roots—Horns—Commissural fibres—Nerve endings—Motor end-plates.

Psycho-sensory Motor Paths : Conscious sensibility—Voluntary motion—Reflex arc—Stages—Grey cortical matter of brain—Laulanié—Medulla—Cerebellum—Nuclei of mesencephalon—Cerebral cortex—Gyrus, precentral and postcentral—Fissures of Rolandi and Sylvius—Fasciculi—Spinal cord—Decussation—Medulla—Pons—Cerebral and cerebellar peduncles—Internal capsule—Corona radiata—Pathological degeneration—Sense of touch.

Sensory Fasciculi : Gower's fasciculus—Optic thalamus—Cerebral cortex—Goll's and Burdock's fasciculi—Direct cerebellar fasciculus—Clark's column—Muscular sense.

Motor Fasciculi : Direct pyramidal fasciculus—Corpus striatum—Voluntary motion—Crossed pyramidal fasciculus—Voluntary stimuli and motor co-ordination.

Other Fasciculi.

Degeneration of Nerve Conductors : Fragmentation of axis cylinder—Segmentation and disappearance of myelin—Modifications of normal electric reactions—Peripheral neuro-motor elements—Myopathies.

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II.—HEAD AND TRUNK.

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Of the Neck : Platysma, sterno-cleido-mastoid, scaleni, omohyoid, stylohyoid, digastric, mylohyoid, posterior muscles.

Principal Anterior Muscles of the Trunk : Pectoralis major, pectoralis minor, serratus anterior, obliquus abdominis externus, obliquus abdominis internus, rectus abdominis.

Principal Posterior Muscles of the Trunk : Trapezius, supraspinatus, nfraspinatus, rhomboidei, teres major, teres minor, latissimus dorsi, sacrospinalis.

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Principal Lateral and Posterior Muscles of the Forearm : Brachio-radialis, extensor carpi radialis longus, extensor carpi radialis brevis, extensor digitorum communis, extensor digiti quinti proprius, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor carpi ulnaris.

Principal Muscles of the Hand : Thenar eminence: Abductor pollicis brevis, flexor brevis, adductor, opponens pollicis—Hypothenar eminence: Abductor digiti quinti, flexor brevis, opponens, four lumbricales, interossei dorsales.

Brachial Plexus : Origin, course, distributed function, points of stimulation, average response of the nerves: Axillary, musculo-cutaneous, radial, median, ulnar, and medial cutaneous, zones of cutaneous sensibility. *Pages* 48–74

IV.—LOWER LIMB.

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Principal Posterior Muscles of the Thigh : Glutæus maximus, glutæus medius, tensor fasciæ latæ, biceps femoris, semimembranosus, semitendinosus.

Principal Posterior Muscles of the Leg and Foot : Gastrocnemius (two heads), soleus, flexor, digitorum longus, flexor hallucis longus, tibialis posterior.

Plantar Muscles : Adductor hallucis, flexor digitorum brevis, abductor digiti quinti, lumbricales, flexor hallucis brevis, flexor digiti quinti brevis.

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ATLAS OF ELECTRO-DIAGNOSIS AND THERAPEUTICS

I.—SENSORY MOTOR NERVE PATHS.

(*Plates I., II., III., and IV.*)

THE sensory motor nerve paths are composed of special cellular elements, *neurons*, provided with protoplasmic processes which receive stimuli, and of *conducting fibres*, which are special cylindrical processes of the neurons, and which transmit the stimuli.

A distinction is made between the *peripheral neurons*, sensory and motor, and the medullary or encephalic *central neurons*, which contain the grey matter. The conductors, sensory and motor fibres, provided with a myelin sheath, constitute the *peripheral nerves*, the *plexuses*, the *spinal roots*, and the *white matter of the spinal cord and the encephalon*. The conductors are connected at different stages with the intermediate neurons, and the chains which result therefrom are more or less long and complex.

It would seem that in these connexions the contact associations are variable; that the protoplasmic processes of the neurons are mobile; and that they recede from or approach the ends of the cylindrical processes which face them. In this way certain phenomena could be explained—*e.g.*, anæsthesia, paralysis, sleep, memory.

Anatomically and physiologically, we distinguish the unconscious paths, called reflex, from the psycho-sensory motor paths.

Reflex Paths.—The stimuli (shock, contact, heat, etc.) collected by the sensory nerve endings of the skin and of the

various senses are conducted by sensory nerves to the ganglionic cells of the posterior roots of the spinal cord, and by the latter to the posterior horns. They are thence transmitted to the motor cells of the anterior horns, either directly at the same level of the spinal cord, or at a higher level by ascending commissural fibres. Under the stimulus of the sensory nerve endings, the cells of the anterior horns send to the muscles the motor impulses by the anterior roots and peripheral motor nerves. These last join the muscles and terminate in special arborisations called motor end-plates, distributed in the proportion of one end-plate at least to one fasciculus of muscular fibres.

Psycho-sensory Motor Paths.—The psycho-sensory motor paths, or paths of conscious sensibility and voluntary motion, have the same sensory and motor peripheral neurons and the same peripheral conductors as the reflex paths, but they present besides medullary and encephalic paths more or less complicated. They are branches of the reflex arc, which comprise the multiple stages, crossings and spinal, bulbar, cerebellar and cerebral connexions, which all end in the grey cortical matter of the brain.

All nervous actions are, moreover, reflex, for they have all at least one stage of reflexion in the grey matter (Laulanié). The most direct motor stimuli go to the muscles only by the medium of the anterior horn cells. The diagram on Plate IV. gives a bird's-eye view of these conscious sensory motor paths, such as they appear to be from the data of experimentation and of normal and pathological microscopic anatomy.

The **neurons** of these different paths are situated in the grey matter at different levels of the spinal cord corresponding to the different segments of the body: in the *medulla*, where are to be found the important centres of respiration, of phonation, and of the movements of the heart; in the cerebellum, which appears to hold under its control the sense of touch, equilibrium and co-ordination of movements, particularly those of walking; in the *nuclei of the mesencephalon*, the optic thalamus for the sensory paths, the corpus striatum for the motor paths; lastly, in the sensory motor area of the *cerebral cortex*, the precentral gyrus and the postcentral gyrus bordering on the

PLATE I.

ELEMENTS OF NERVE PATHS. (After Ranvier).

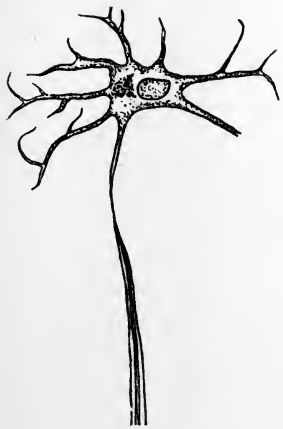


FIG. 1.

Pyramidal cell of anterior horns with its protoplasmic extensions and axis-cylinder.

FIG. 2.

Nerve fibre of a spinal fasciculus, axis-cylinder and myelin sheath.

FIG. 3.

Peripheral nerve fibre, axis-cylinder, myelin sheath and external sheath of Schwann.

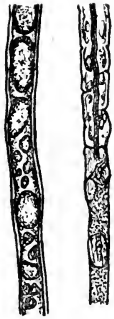


FIG. 4.

Peripheral nerve fibres in degeneration.

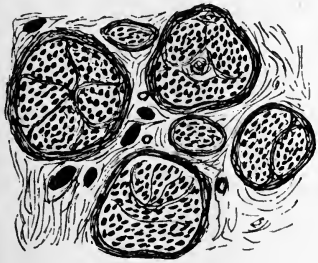
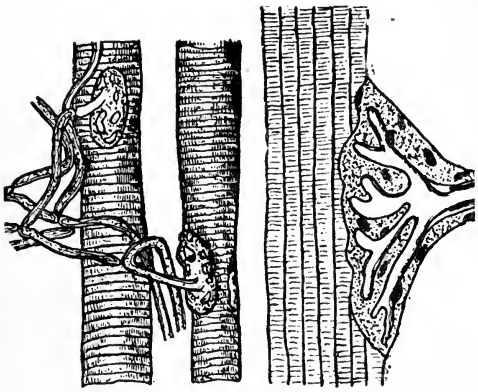


FIG. 5.

Section of a peripheral nerve: fasciculi of nerve fibres, sheaths and perifascicular tissue, fat, and bloodvessels.



FIGS. 6 AND 7.

Motor end-plates: terminal of the nerve fibres in the muscles.

PLATE II.

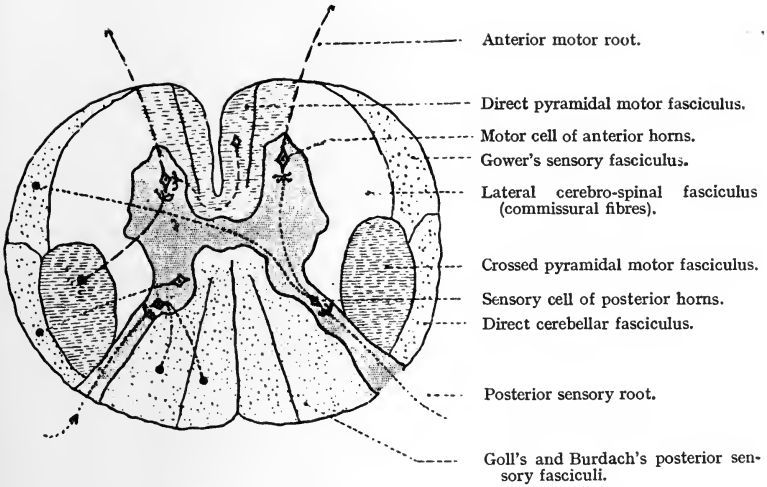

Anterior motor root.
Direct pyramidal motor fasciculus.
Motor cell of anterior horns.
Gower's sensory fasciculus.
Lateral cerebro-spinal fasciculus (commissural fibres).
Crossed pyramidal motor fasciculus.
Sensory cell of posterior horns.
Direct cerebellar fasciculus.
Posterior sensory root.
Goll's and Burdach's posterior sensory fasciculi.

FIG. 1.—DIAGRAM OF THE SPINAL CORD. (In part after Testut.)

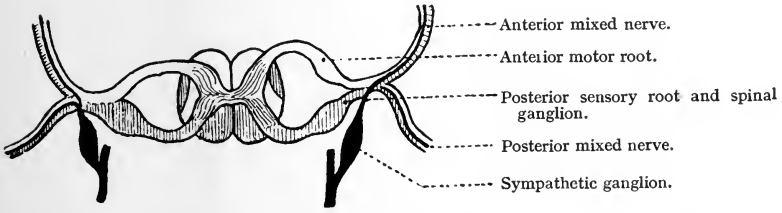


FIG. 2.—ORIGIN OF SPINAL NERVES. (After Testut.)

fissures of Rolando and Sylvius, where are found the principal centres of sensibility, of thought, and of voluntary movement (Plate III.).

The **conductors** in the spinal cord and the brain (white matter) are grouped in fasciculi of homogeneous fibres, sensory or motor, corresponding with particular functions and tracts; they follow each other in the *spinal cord*, where they are connected with the terminals of the peripheral conductors, and where certain fibres decussate and pass to the opposite side; in the *medulla*, where several fasciculi undergo a similar crossing; in the *pons*, the *cerebral* and *cerebellar peduncles*, in the *internal capsule*, and in the *corona radiata* as far as the cerebral cortex. The injuries of experimental or pathological degeneration, ascending for the sensory paths, descending for the motor paths, allow us to follow step by step each fasciculus at its different levels.

Here are summed up the principal known characters of these groups of conductors:

Sensory Fasciculi: *Gower's Fasciculus.*—Antero-lateral border of the spinal cord: originates in the cells of the posterior horns of the opposite side, traverses the medulla on the same side, forms connexions in the optic thalamus, and ends in the cerebral cortex on the same side.

Conscious sense of warmth and pain.

Goll's and Burdock's Fasciculi.—Postero-internal zone of the spinal cord: originate in the cells of the posterior horns of the same side, comprise commissural fibres with short paths, and long fibres ending in the cerebral cortex of the opposite side, crossing in the medulla.

Sense of touch.

Direct Cerebellar Fasciculus.—Postero-external border of the spinal cord: originates in the cells of Clark's column (internal base of posterior horns), traverses the medulla without crossing, goes to the cerebellar cortex of the same side, then to the cerebral cortex of the opposite side.

Muscular sense.

Motor Fasciculi: *Direct Pyramidal Fasciculus.*—Middle anterior portion of the spinal cord: comes from the cerebral cortex on the same side, forms connexions in the corpus

striatum, traverses the medulla without crossing, and ends in the anterior horns of the opposite side.

Voluntary motion.

Crossed Pyramidal Fasciculus.—Postero-internal portion of the lateral cord: comes from the cerebral cortex of the opposite side, and ends in the cells of the anterior horns of the same side.

Voluntary stimuli and motor co-ordination.

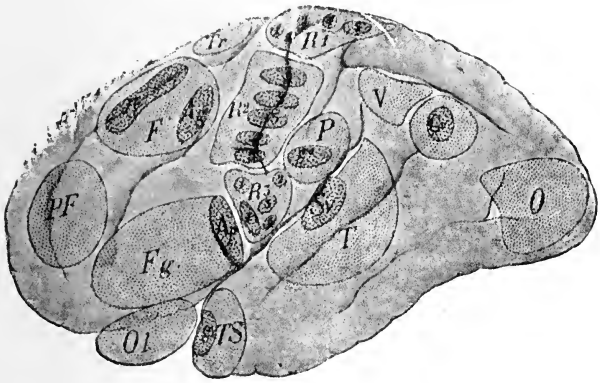
The other fasciculi composing the white matter of the spinal cord and brain are formed of commissural fibres, with a tract more or less long, which bind the right and left portions of the different stages of the cerebro-spinal column.

Degeneration of Nerve Conductors (*Fragmentation of the Axis-Cylinder, Segmentation, then Disappearance of the Myelin*). —The degeneration of the nerve cords resulting from central or peripheral injury gives rise to motor, sensory, and trophical troubles within well-defined limits, and, in the same areas, to *important modifications of the normal electric reactions* of nerves and muscles to different forms of current. These last modifications, the research for which is the very object of electro-diagnosis, vary greatly in their distribution, and also in their own characters, according to the region of injury and the extent of degeneration. Abolition of excitability of nerves and muscles to the faradic current, diminution of excitability to the galvanic current, inversion of formula, slow contraction, are only entirely observed when are injured directly the *peripheral neuro-motor elements*—that is, nerves, plexuses, roots, or the bulbar or spinal motor neurons (cells of the anterior horns) from which they emanate. Cortical injuries or injuries to the cerebral or cerebellar nuclei, and isolated injuries to the medullary or encephalic conductors, are habitually followed by only slight quantitative modifications (hypo- and sometimes hyper-excitability).

Myopathies, affections of muscles without nerve degeneration, also occasion little or no modification of electric reactions.

The study of the plexuses, of the peripheral nerves, and of the areas they supply, is therefore particularly important from an electro-diagnostic and electro-therapeutic point of view.

PLATE III.



CEREBRAL LOCALISATIONS. (After Okinczyc.)

PF, anterior frontal area (thought, mental lesions).

F, frontal area: *Ag*, agraphia.

Ty, combined movements of the head and eyes.
Tr, movements of the trunk: *Fg*, inferior frontal gyrus.
Ap, motor aphasia: *Ol*, olfactory area.

R_1, R_2, R_3, Rolandic area.

R_1: 1, thigh; 2, knee; 3, ankle; 4, great toe; 5, toes.
R_2: 1, shoulder; 2, elbow; 3, wrist; 4, fingers; 5, thumb.
R_3: 1, superior facial; 2, inferior facial; 3, mouth; 4, larynx; 5, tongue.

P, parietal area: *Go*, movements of the eyeballs.

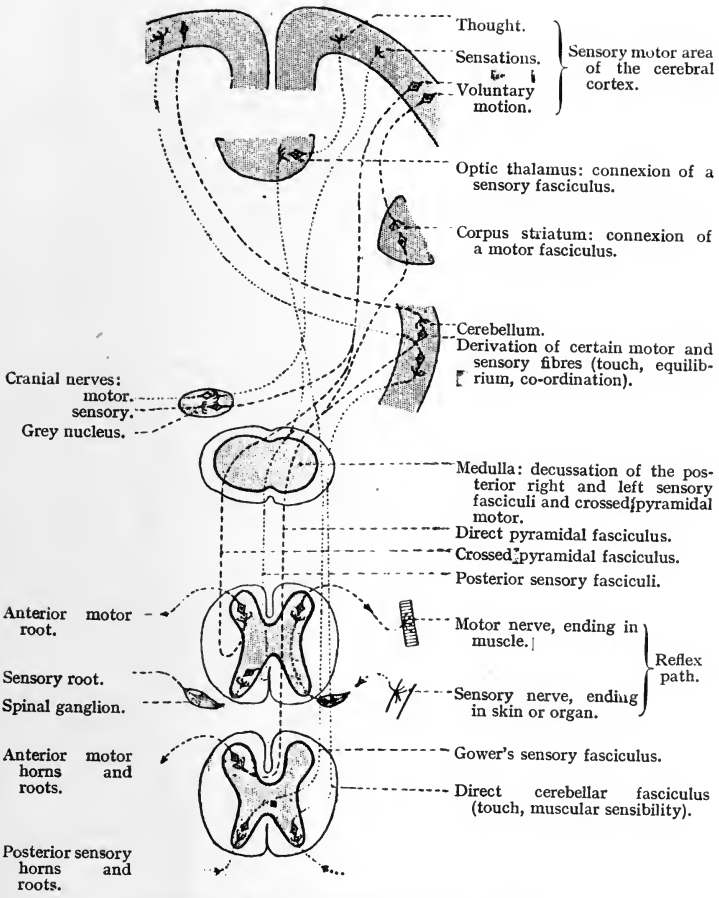
V, vision: *Cv*, verbal blindness.

T, temporal area: *Sv*, verbal deafness.

TS, temporo-sphenoidal area: *G*, taste.

O, occipital area.

PLATE IV.


Thought.
Sensations.
Voluntary motion.
Sensory motor area of the cerebral cortex.
Optic thalamus: connexion of a sensory fasciculus.
Corpus striatum: connexion of a motor fasciculus.
Cerebellum.
Derivation of certain motor and sensory fibres (touch, equilibrium, co-ordination).
Cranial nerves: motor. sensory.
Grey nucleus.
Medulla: decussation of the posterior right and left sensory fasciculi and crossed pyramidal motor.
Direct pyramidal fasciculus.
Crossed pyramidal fasciculus.
Posterior sensory fasciculi.
Anterior motor root.
Motor nerve, ending in muscle.
Reflex path.
Sensory root.
Spinal ganglion.
Sensory nerve, ending in skin or organ.
Anterior motor horns and roots.
Gower's sensory fasciculus.
Direct cerebellar fasciculus (touch, muscular sensibility).
Posterior sensory horns and roots.

SENSORY MOTOR CEREBRO-SPINAL PATHS.

Scheme of the principal known paths.

II.—HEAD AND TRUNK.

Principal Muscles of the Face.

(*Plates V., VI., VII.*)

All supplied by the facial nerve, except the musculus temporalis, the masseter, and the levator palpebræ superioris.

Temporalis.—*Origin :* temporal fossa.

Insertion : coronoid process of the mandible. Masticator.

Nerve : mandibular division of the trigeminal.

Motor point : middle of the temporal fossa.

N.C.Con.=3·5; P.C.Con.=4·5.*

Masseter.—*Origin :* zygomatic arch.

Insertion : angle of the mandible. Masticator.

Nerve : mandibular division of the trigeminal.

Motor point : a finger's breadth above the angle of the mandible.

N.C.Con.=3·5; P.C.Con.=5.

Epicranius.—*Origin :* galea aponeurotica.

Insertion : skin of the orbital region. Mobilises and wrinkles the skin of the forehead.

Nerve : temporal branches of the facial.

Motor point : frontal tuberosity.

N.C.Con.=1·5 ; P.C.Con.=3.

Orbicularis Oculi.—*Attachments :* medical commissure of the orbit and skin of the lateral angle of the eye.

Closes the eyelids.

Nerve : superior division of the facial.

Motor point : a few millimetres below the lateral angle of the eye.

N.C.Con.=4; P.C.Con.=5.

* N.C.C. means negative closing contraction; and P.C.C., positive closing contraction. The numbers indicate in milliampères the average intensity of the galvanic current to obtain Con.—that is to say, the contraction of the muscle at N.C. and P.C.

Levator Palpebræ Superioris.—*Origin:* at the back of the orbit.

Insertion: skin and tarsal cartilage of the eyelid.

Nerve: superior division of the oculo-motor.

Compressor Naris.—*Attachments:* aponeurosis at the bridge of the nose, and skin of the ala of the nose. Raises the ala, produces longitudinal wrinkles on the bridge of the nose.

Nerve: middle division of the facial.

Motor point: middle of the nasal septum.

N.C.Con.=4; P.C.Con.=5.

Caput Angulare.—*Origin:* medial angle of the orbit.

Insertion: skin of the upper lip, and of the ala of the nose.

Nerve, middle division of the facial.

Motor point: middle of the groove between the nose and the cheek.

N.C.Con.=4; P.C.Con.=5.

Caput Zygomaticum and Zygomaticus.—*Origin:* malar bone.

Insertion: skin of the upper lip.

Raise and protrude the upper lip.

Nerve: middle division of the facial.

Motor point: 2 centimetres below the lateral angle of the eye.

N.C.Con.=5; P.C.Con.=6·5.

Buccinator.—*Origin:* alveolar borders of the maxilla and the mandible.

Insertion: mucous membrane of the angle of the mouth.

Hollows the cheeks.

Nerve: division of the facial.

Motor point: in the mouth, in front of the masseter.

N.C.Con.=2·5; P.C.Con.=3·5.

Orbicularis Oris.—Superior fibres and inferior fibres join at the angle of the mouth.

Closes the lips.

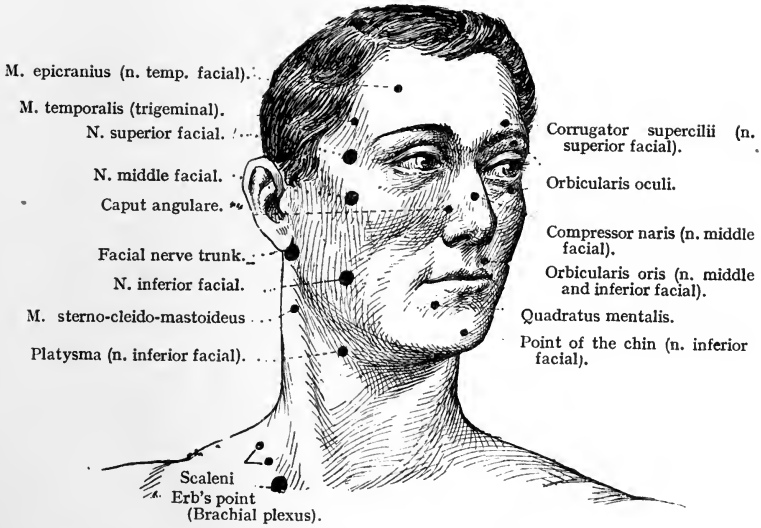
Nerve: middle division of the facial (superior fibres), and inferior division of the facial (inferior fibres).

Motor points: above and below the angle of the mouth.

N.C.Con.=5·5; P.C.Con.=7.

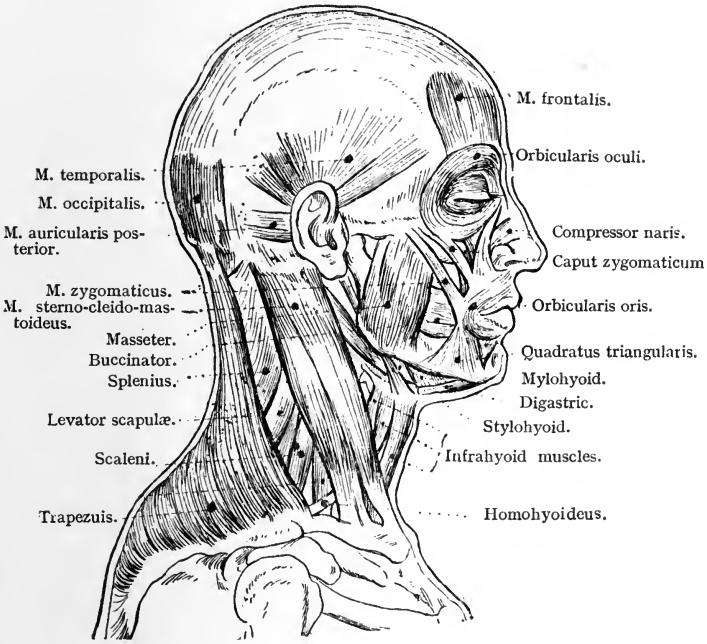
Triangularis Oris.—*Origin:* skin of the angle of the mouth.

PLATE V.



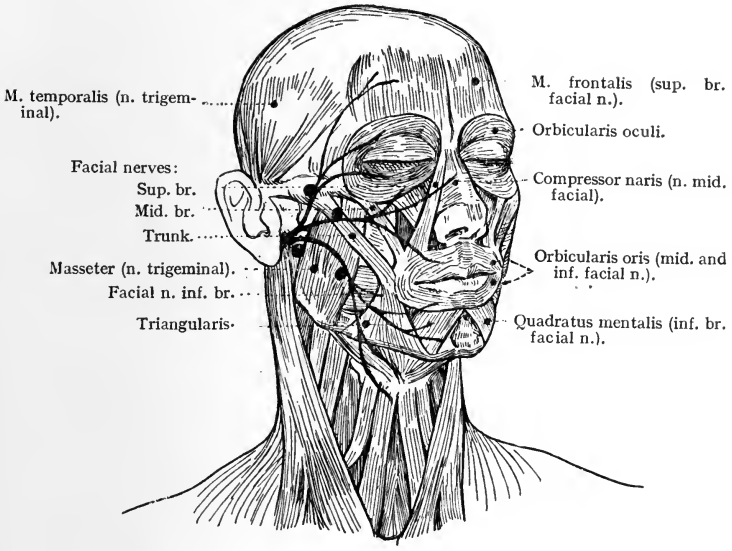
HEAD AND NECK: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

PLATE VI.



FACE AND NECK: SUPERFICIAL MUSCLES (MOTOR POINTS).

PLATE VII.



FACIAL NERVE DISTRIBUTION (MOTOR POINTS).

Insertion: mandible.
Lowers the angle of the mouth.
Nerve: inferior division of the facial.
Motor point: the inferior border of the maxilla.
N.C.Con.=6; P.C.Con.=7.

Principal Muscles of the Neck.

(*Plate VIII.*)

Platysma.—*Origin:* skin of the chin and mandible.
Insertion: skin and cellular tissue over the clavicle. Lowers the skin of the chin and wrinkles the skin of the neck.
Nerve: inferior division of the facial.
Motor point: 1 centimetre below and in front of the angle of the mandible. (*N.B.*—Press lightly to avoid the stimulation of deeper muscles.)
N.C.Con.=5; P.C.Con.=6·5.
Sterno-cleido-mastoid.—*Origin:* sternum (sternal head) and medial third of the clavicle (clavicular head).
Insertion: mastoid process.
Flexes the head and inclines it laterally.
Nerve supply: spinal and third cervical nerve.
Motor point: about 2 centimetres below the mastoid.
N.C.Con.=3; P.C.Con.=4.
Scaleni.—*Origin:* transverse processes of the cervical vertebræ.
Insertion: superior aspect of the first and second ribs; deeply situated, accessible only above the clavicle, between the trapezius and the sterno-mastoid.
Incline the head to one side, raise the ribs; muscles of inspiration.
Nerve supply: third, fourth, fifth, and sixth cervical nerves.
Motor point: a little outside the origin of the sterno-mastoid.
N.C.Con.=3·5; P.C.Con.=4·5.
Omohyoid.—Descends obliquely from the hyoid bone to the superior border of the scapula, under the platysma, the

sterno-mastoid, and the trapezius; accessible above the clavicle, between these last two muscles.

Tensor of the cervical aponeurosis.

Nerve: hypoglossal.

N.C.Con.=2·5; P.C.Con.=3·5.

Stylohyoid, Digastric, and Mylohyoid.—These may be stimulated through the platysma of the neck; their electric examination is difficult and very rarely necessary (see the figures for the motor points).

Posterior Muscles.—All deeply situated, they are inaccessible, except the *splenius*, which is on the lateral border of the trapezius, and which one can stimulate between this muscle and the sterno-mastoid; supplied by the cervical nerves; it flexes the head forward and inclines it laterally.

Principal Anterior Muscles of the Trunk.

(*Plates IX., X., XIII., XIV.*)

Pectoralis Major.—*Origin:* medial two-thirds of the clavicle, the manubrium, the sternum, and cartilages of the first six ribs.

Insertion: humerus, lateral border of the intertubercular groove. Adductor and internal rotator.

Nerve: of the pectoralis major and both anterior thoracic branches of the brachial plexus.

Motor point: above and a little outside the nipple.

N.C.Con.=2·5; P.C.Con.=4.

Pectoralis Minor.—*Origin:* third, fourth, and fifth ribs.

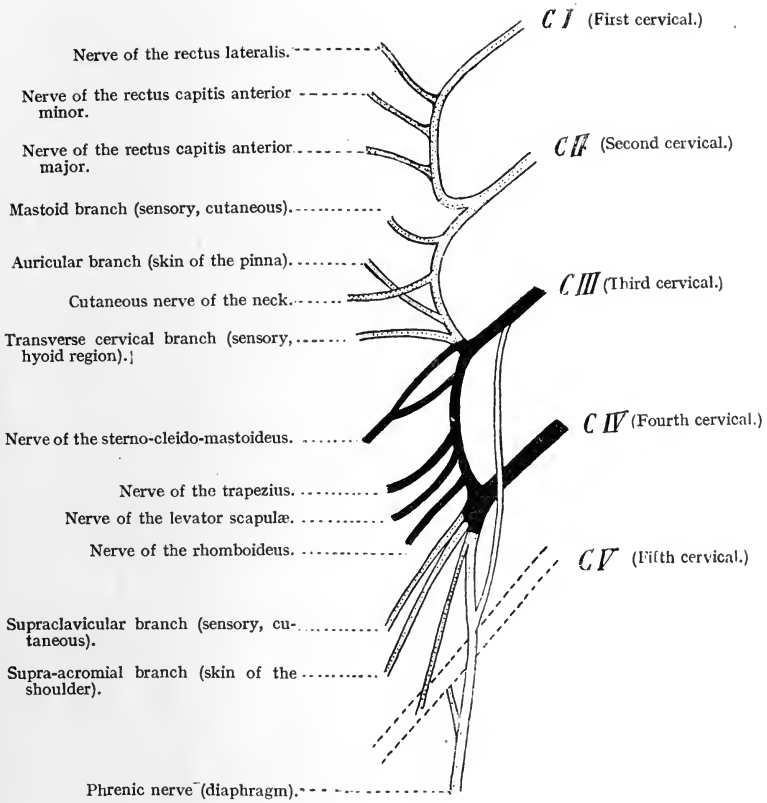
Insertion: coracoid process (brachial plexus), deep-seated, covered by the pectoralis major; inaccessible.

Serratus Anterior.—*Origin:* by nine or ten slips from the lateral aspect of the first nine or ten ribs.

Insertion: spinal border of the scapula in all its height. Rotator of the scapula, elevator of the shoulder (about one-third of this movement), muscle of inspiration.

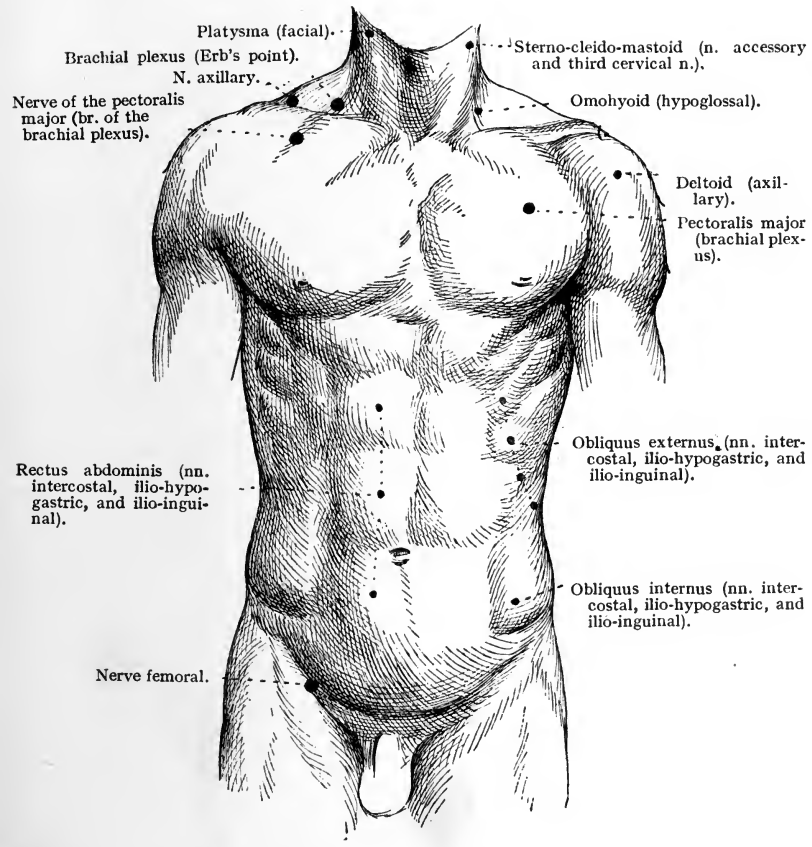
Nerve: of the serratus anterior branch of the brachial plexus (can be stimulated directly at the apex of the axilla).

PLATE VIII.


C I (First cervical.)
Nerve of the rectus lateralis.
Nerve of the rectus capitis anterior minor.
Nerve of the rectus capitis anterior major.
C II (Second cervical.)
Mastoid branch (sensory, cutaneous).
Auricular branch (skin of the pinna).
Cutaneous nerve of the neck.
C III (Third cervical.)
Transverse cervical branch (sensory, hyoid region).
C IV (Fourth cervical.)
Nerve of the sterno-cleido-mastoideus.
Nerve of the trapezius.
Nerve of the levator scapulæ.
Nerve of the rhomboideus.
C V (Fifth cervical.)
Supraclavicular branch (sensory, cutaneous).
Supra-acromial branch (skin of the shoulder).
Phrenic nerve (diaphragm).

CERVICAL PLEXUS. (Plan after Testut.)

PLATE IX.


Platysma (facial).
Brachial plexus (Erb's point).
N. axillary.
Nerve of the pectoralis major (br. of the brachial plexus).
Sterno-cleido-mastoid (n. accessory and third cervical n.).
Omohyoid (hypoglossal).
Deltoid (axillary).
Pectoralis major (brachial plexus).
Obliquus externus (nn. intercostal, ilio-hypogastric, and ilio-inguinal).
Rectus abdominis (nn. intercostal, ilio-hypogastric, and ilio-inguinal).
Obliquus internus (nn. intercostal, ilio-hypogastric, and ilio-inguinal).
Nerve femoral.

TRUNK, ANTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

Motor points: only the inferior fasciculi are accessible—at the inferior border of the axillary hollow.

N.C.Con.=5·5; P.C.Con.=7.

Obliquus Abdominis Externus.—Descends from the last seven ribs towards the linea alba and femoral arch. Laterally a muscular area. Anteriorly an aponeurotic area. Its costal digitations are interlaced with those of the serratus anterior.

Flexor of the thorax on the pelvis; muscle of expiration. Forms the abdominal wall.

Nerves: intercostal, ilio-hypogastric, and ilio-inguinal.

Motor points (6): Lateral region below those of the serratus magnus.

N.C.Con.=3; P.C.Con.=4·5.

Obliquus Abdominis Internus.—*Origin:* stretches itself like a fan from the iliac crest and femoral arch.

Insertion: the last three ribs. Situated below the obliquus externus, its inferior fasciculi are accessible only under the aponeurosis of this muscle, above the femoral arch. Flexes the thorax laterally on the pelvis; forms the abdominal wall.

Nerves: intercostal, ilio-hypogastric, and ilio-inguinal.

Motor points: above the femoral arch.

N.C.Con.=3·5; P.C.Con.=4·5.

Rectus Abdominis.—Formed by three or four muscular sections, separated by aponeurotic fibres. Goes from the body of the pubis to the xiphoid process and the anterior termination of the fifth, sixth, and seventh ribs. Flexor of the thorax on the pelvis; muscle of expiration. Forms the abdominal wall.

Nerve-supply: the two superior sections by the last intercostal nerves; the two inferior sections by the ilio-hypogastric and ilio-inguinal nerves.

Motor points: middle of each muscular section.

N.C.Con.=3·5; P.C.Con.=5.

Principal Posterior Muscles of the Trunk.

(*Plates XI., XII., XIII., XIV.*)

Trapezius.—*Origin :* vertical medial posterior line of the spinous processes, from the occipital bone to the twelfth dorsal vertebra.

Insertions : posterior surface of the lateral third of the clavicle, acromion, and upper border of the spine of the scapula.

Physiologically it is especially a muscle of the shoulder. Adductor and elevator of the shoulder. Fixes and rotates the scapula (with the serratus anterior). Auxiliary muscle for inspiration.

Double nerve-supply : Accessory nerve and nerve of the trapezius. Branch of the brachial plexus.

Motor points : clavicular fasciculi; 4 or 5 centimetres above the clavicle; acromial and spinous fasciculi above the spine of the scapula; inferior fasciculi below the medial angle of the scapula.

N.C.Con.=1·5; P.C.Con.=3.

Supraspinatus and Infraspinatus.—*Origin :* supra- and infra-spinous fossæ of the scapula.

Insertion : great tuberosity of the humerus. The supra-spinatus is the elevator of the arm, and the infraspinatus the external rotator.

Nerve-supply : suprascapular nerve (brachial plexus).

Motor points—Supraspinatus : lateral angle of the supra-spinous fossa. Covered by the trapezius, it is accessible only when the trapezius is atrophied. *Infraspinatus :* accessible between the trapezius and the deltoid in the middle of the infraspinous fossa.

N.C.Con.=6; P.C.Con.=7.

Rhomboidei.—*Origin :* spinous processes of the seventh cervical and the first five thoracic vertebræ.

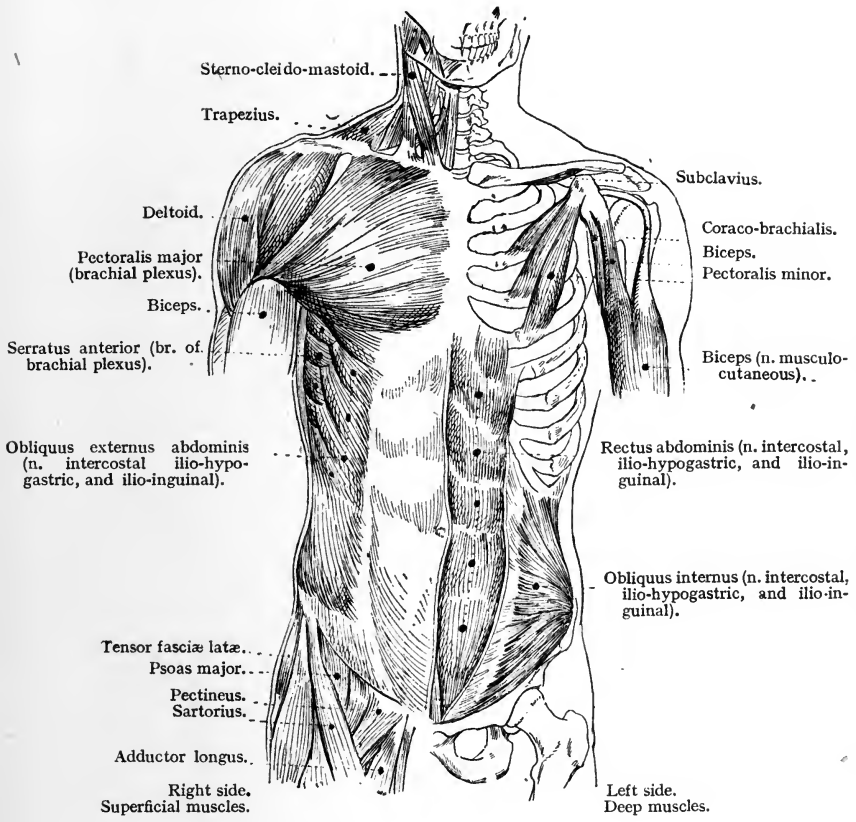
Insertion : vertebral margin of the scapula.

Adductor : fixes and elevates the shoulder.

Nerve : of the rhomboids (brachial plexus).

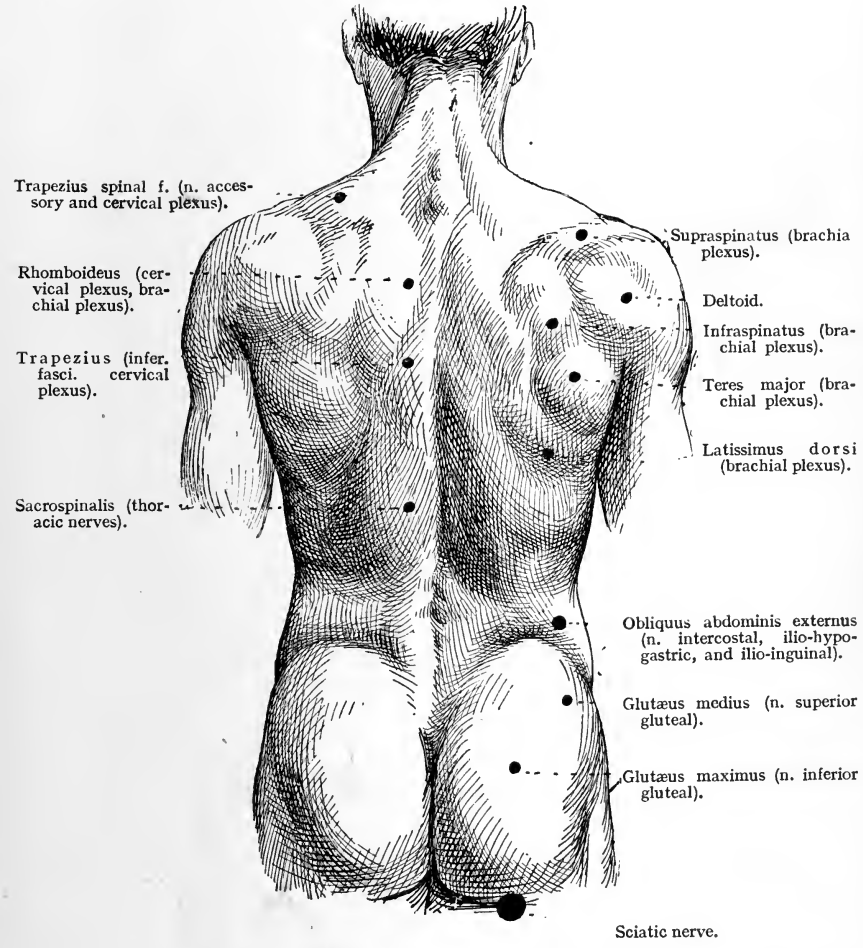
Motor point : on the three-fourths concealed by the trapezius.

PLATE X.



MUSCLES OF THE TRUNK, ANTERIOR ASPECT: MUSCLES, NERVE-SUPPLY, AND MOTOR POINTS.

PLATE XI.


Trapezius spinal f. (n. accessory and cervical plexus).
Rhomboideus (cervical plexus, brachial plexus).
Trapezius (infer. fasci. cervical plexus).
Sacrospinalis (thoracic nerves).
Supraspinatus (brachia plexus).
Deltoid.
Infraspinatus (brachial plexus).
Teres major (brachial plexus).
Latissimus dorsi (brachial plexus).
Obliquus abdominis externus (n. intercostal, ilio-hypogastric, and ilio-inguinal).
Glutæus medius (n. superior gluteal).
Glutæus maximus (n. inferior gluteal).
Sciatic nerve.

TRUNK, POSTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

The inferior fasciculi are accessible only below the outer margin of the trapezius, at the inferior angle of the scapula.

N.C.Con.=3·5; P.C.Con.=6.

Teres Minor and Teres Major.—*Origin :* axillary border of the scapula.

Insertion—minor : head of humerus.

Insertion—major : intertubercular groove.

Internal rotators of the arm.

Nerve-supply—teres minor : axillary. *Teres major :* special branch of the brachial plexus.

Motor point : only the teres major is accessible (with difficulty), near the superior margin of the latissimus dorsi, towards the axilla.

Latissimus Dorsi.—*Origin :* spinous processes of the vertebræ from the sixth thoracic. Sacral and iliac crests.

Insertion : medial border of the intertubercular groove. Adductor of the arm, and internal rotator. Elevator of the trunk on the arms.

Nerve : special branch of the brachial plexus.

Motor point : on the superior margin of the muscle at the border of the axilla.

N.C.Con.=4·2; P.C.Con.=6.

Sacrospinalis.—Lying on the vertebral grooves, concealed by the latissimus dorsi. Can be stimulated through the aponeurosis of the latter, at its inferior portion.

Extension of the vertebræ. Upright position.

Nerve-supply : lumbo-thoracic nerves.

Motor point : above the waist about 10 centimetres from the spinous processes.

N.C.Con.=4; P.C.Con.=6.

Cranial Nerves.

Twelve pairs of nerves emerge from the encephalon or the medulla; they are:

I. Olfactory.
II. Optic.
III. Oculo-motor.
IV. Trochlear.
V. Trigeminal.
VI. Abducent.
VII. Facial.
VIII. Acoustic.
IX. Glossopharyngeal.
X. Vagus.
XI. Accessory.
XII. Hypoglossal.

The olfactory, optic, and acoustic nerves are exclusively nerves of *the special senses*.

The oculo-motor, the abducent, the facial, the accessory, and the hypoglossal are exclusively *motor*. The trigeminal, the glossopharyngeal, and the vagus are *both sensory and motor*.

Nerves of the Special Senses.

The **Olfactory Nerve,** or rather the olfactory nerves, which are numerous, leave the olfactory bulb, which is attached to the skull by the olfactory fascia, traverse the cribriform plate of the ethmoid bone, and are distributed to the mucous membrane of the nasal chambers.

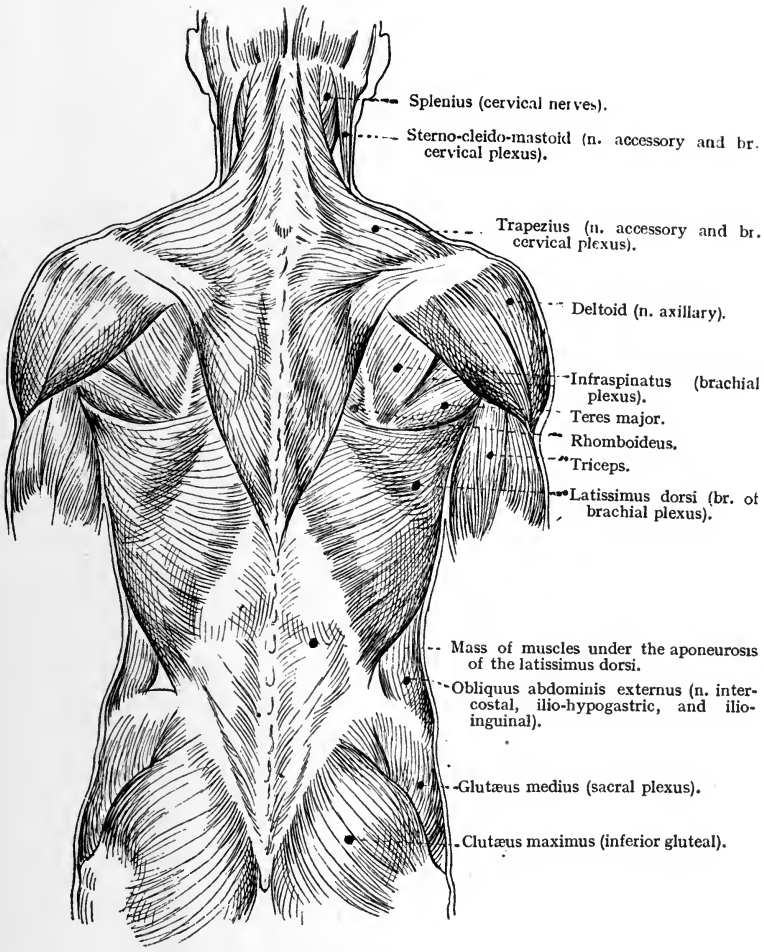
The **Optic Nerve** leaves the optic chiasma where the two optic nerves partially cross each other, proceeds towards the orbit, which it penetrates, and terminates in the eyeball, being continuous with the fibres of the retina. The galvanic stimulus of the eyeball with 2 or 3 milliampères produces luminous impressions (phosphenes).

The **Acoustic Nerve** leaves the medulla, reascends towards the internal acoustic meatus, at the back of which it is distributed to the different organs of the inner ear. It is generally admitted that it is the stimulation of this nerve (continuous current) that produces voltaic vertigo, a normal phenomenon, the modifications of which are important in the investigation of certain affections of the ear. To produce this vertigo we generally apply the two electrodes in front of the tragus; it is obtained normally with a current of 2 to 5 milliampères. The head leans towards the side of the positive pole.

Oculo-motor Nerves.

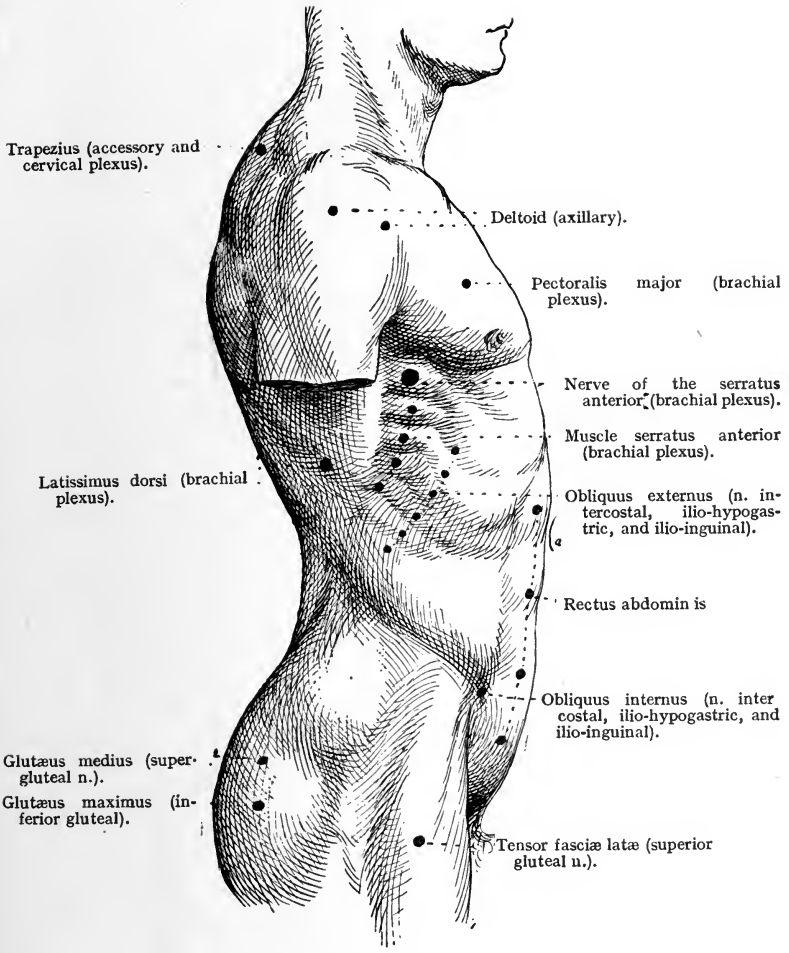
The **Oculo-motor Nerve** leaves the cerebral peduncle, follows the wall of the cavernous sinus, and penetrates into the orbit by the sphenoidal fissure. It is distributed to the muscles of the eye: the superior branch to the muscles rectus superior and levator palpebræ superioris, the inferior branch to the muscles rectus medialis, rectus inferior and obliquus inferior.

PLATE XII.


Splenius (cervical nerves).
Sterno-cleido-mastoid (n. accessory and br. cervical plexus).
Trapezius (n. accessory and br. cervical plexus).
Deltoid (n. axillary).
Infraspinatus (brachial plexus).
Teres major.
Rhomboideus.
Triceps.
Latissimus dorsi (br. of brachial plexus).
Mass of muscles under the aponeurosis of the latissimus dorsi.
Obliquus abdominis externus (n. intercostal, ilio-hypogastric, and ilio-inguinal).
Glutæus medius (sacral plexus).
Glutæus maximus (inferior gluteal).

MUSCLES OF THE TRUNK, POSTERIOR ASPECT: NERVE SUPPLY AND MOTOR POINTS.

PLATE XIII.


Trapezius (accessory and cervical plexus).
Deltoid (axillary).
Pectoralis major (brachial plexus).
Nerve of the serratus anterior (brachial plexus).
Muscle serratus anterior (brachial plexus).
Latissimus dorsi (brachial plexus).
Obliquus externus (n. intercostal, ilio-hypogastric, and ilio-inguinal).
Rectus abdomin is
Obliquus internus (n. inter costal, ilio-hypogastric, and ilio-inguinal).
Glutæus medius (superior gluteal n.).
Glutæus maximus (inferior gluteal).
Tensor fasciæ latæ (superior gluteal n.).

TRUNK, LATERAL ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

The **Trochlear Nerve** leaves the dorsal surface of the mesencephalon and proceeds towards the orbit, where it terminates in the obliquus superior.

The **Abducent Nerve** leaves the medulla and goes to the orbit, where it supplies the rectus lateralis.

The **Accessory Nerve**, motor, originates from many roots, bulbar and spinal (these last ascending), emerges from the cranium by the jugular foramen, and is distributed to the neck in two principal branches: one for the muscles of the pharynx and the larynx, the other for the trapezius and the sternomastoideus.

The **Trigeminal Nerve**, mixed nerve, especially sensory, originates from the pons by two roots, the principal one sensory, and the other a small motor nerve, which join the Gasserian ganglion on the anterior aspect of the petrous portion of the temporal bone; then it divides into three branches :

The *Ophthalmic Nerve*, sensory, proceeds towards the orbit, in which it is divided into nasal, lachrymal, palpebral and frontal branches.

The *Maxillary Nerve*, sensory, proceeds in front under the floor of the orbit, and emerges on the face by the infra-orbital foramen; it is divided into lachrymal, osseous, dental and cutaneous branches.

The *Mandibular Nerve*, mixed branch, comprises the fibres of the motor root (masticator nerve), leaves the cranium by the oval foramen, furnishes branches for the pterygoid muscles, the temporalis and the masseter, and for the two sensory nerves, inferior dental and lingual; this last, the mucous branches of which preside over the sense of taste, receives the chorda tympani (an anastomosis of the facial), and helps to provide the roots of the submaxillary ganglion, which regulates the secretion of the submaxillary gland.

The electric current provokes on the lingual mucous membrane, by stimulation of the lingual nerve, special sensations which are different with the anode (a bitter and burning taste) and the cathode (a metallic taste). Further, the stimulation (probably of the chorda tympani), by an electrode applied to the submaxillary region, produces a marked hypersecretion of saliva.

The **Glossopharyngeal Nerve,** motor and sensory, leaves the cranium by the jugular foramen; descends alongside the internal carotid, then curves in front towards the base of the tongue; furnishes Jacobson's nerve for the cavity of the tympanum and for the anastomoses with the trigeminal; gives branches to the muscles, digastric, stylopharyngeus, styloglossus, and stylohyoid, and the muscles of the pharynx; and terminates in the mucous membrane of the base of the tongue, forming the lingual plexus.

The **Hypoglossal Nerve,** motor, originates in the medulla by ten or twelve convergent roots, emerges from the cranium by the anterior condyloid foramen, and descends, curving itself inwards, towards the base of the tongue, in the muscles of which it terminates, anastomosed with the lingual.

The **Vagus or Pneumogastric Nerve** originates in the medulla, emerges from the cranium by the jugular foramen, descends between the internal jugular vein and the carotid, penetrates into the thorax, joins the œsophagus, traverses the diaphragm with it, and terminates in the abdominal cavity. In its long course it anastomoses with the accessory, the facial, the glossopharyngeal and the hypoglossal; it distributes very numerous branches to the neighbouring organs: pharynx, larynx, œsophagus, heart, lungs, diaphragm, stomach, liver and intestines, for which it forms with the sympathetic chain the important œsophageal, cardiac, pulmonary, cœliac and solar plexuses.

Facial Nerve.

(*Plates V., VI., and VII.*)

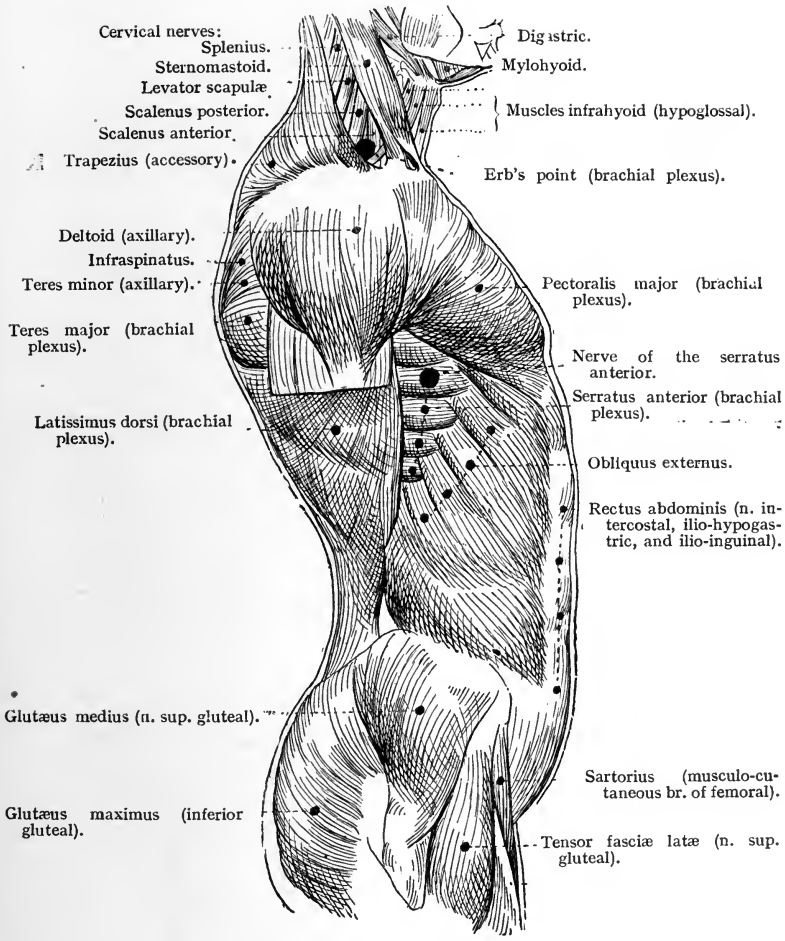
Nerve of the physiognomy, or of expression, supplies the platysma muscles of the head and neck.

Origin.—1. *A bulbar nucleus, called the inferior facial,* which serves all the muscles supplied by the facial, except the frontalis, the corrugator supercilii, and the orbicularis oculi.

2. *A peduncular nucleus, called the superior facial,* reserved for the three muscles mentioned above.

Emergence, Course.—The facial emerges from the fossa lateral to the medulla with the auditory nerve and the inter-

PLATE XIV.



MUSCLES OF THE NECK AND TRUNK, LATERAL VIEW: NERVE SUPPLY AND MOTOR POINTS.

mediate nerve of Wrisberg; it joins them in the internal acoustic meatus, follows the aqueduct of Fallopius, and emerges from the cranium by the stylomastoid foramen. It traverses the parotid and divides into three principal branches, which subdivide for the various muscles of the face.

Collateral Branches.—In the canal of Fallopius, the facial nerve forms the genicular ganglion where Wrisberg's nerve (sensory) terminates, and from this ganglion arise the two superficial petrosal nerves (anastomosed with the trigeminal), the nerve of the muscle stapedius, and the chorda tympani (salivary nerve and that of sense of taste).

At its *emergence from the petrous portion of the bone* it gives off branches for the occipital, posterior and superior auricular, digastric and stylohyoid muscles, also a branch for the muscles and the mucous membrane of the tongue.

Termination.—*The superior branch* is distributed to the anterior auricular muscles, the frontalis, the corrugator supercilii, and the orbicularis oculi. *The middle branch* goes to the caput zygomaticum and the zygomaticus, to the muscles of the nose, and to the superior half of the orbicularis oris.

The *inferior branch* serves the buccinator and muscles of the chin, the lower half of the orbicularis oris, and the platysma of the neck.

Points of Stimulation of the Nerve.—*Principal trunk:* at its emergence from the cranium, below the ear, between the mastoid and the maxillary.

Superior branch: on the temporalis, a little outside and above the lateral angle of the orbit.

Middle branch: on the zygomatic arch, below the medial angle of the orbit.

Inferior branch: a little above and in front of the angle of the lower jaw.

N.C.Con.=4; P.C.Con.=5·5.

Pathology.—In **facial paralysis of a central origin** (cortical, or of the oval centre), the muscles supplied by the inferior facial (bulbar nucleus) are the only ones affected; the orbicularis oculi is immune, and the electric reactions are but slightly modified.

In **bulbar and peripheral paralysis,** intra- or extra-temporal,

all the muscles of the face are affected, and the modifications of electric reactions are very characteristic. In addition, in paralysis of an intratemporal origin, the salivary secretion and sense of taste are diminished in the anterior half of the tongue (chorda tympani). The tongue is deviated (branch of the digastric and of the styloglossus) and the auditory sense is exaggerated (branch of the stapedius).

Spinal Nerves.

(*Plate II.*)

Thirty-one pairs of nerves having their origin in the spinal cord leave the spinal canal by the intervertebral foramina: eight cervical pairs, twelve thoracic, five lumbar, five sacral, and one coccygeal.

Each nerve has an *anterior motor root* and a *posterior sensory root* (the latter, provided with a spinal ganglion, receives a branch from the sympathetic chain), and is divided into two branches: one anterior and one posterior, both mixed sensory and motor.

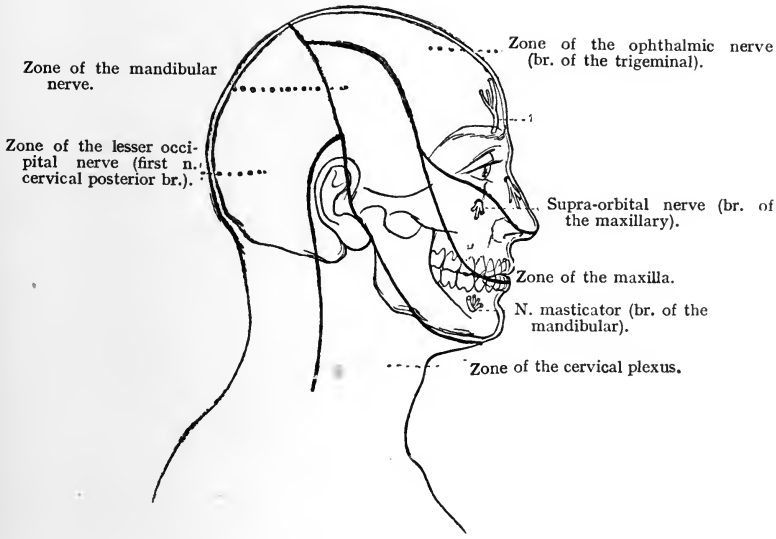
The *posterior branches*, short, slender, symmetrical, independent, are distributed to the muscles of the vertebra grooves and to the skin of the cervicodorsal region.

The voluminous *anterior branches* are associated with the homologues of the pairs situated above and below, and form important plexuses (cervical, brachial, lumbar, sacral).

Cervical Plexus (*Plate XV.*).—Formed by the first four cranial nerves, is situated between the prevertebral muscles on the inside, the splenius and the sternomastoid on the outside; it forms three regular arches. It supplies five *superficial sensory branches* for the pinna of the ear, the occipital, suprahyoid and the subclavicular regions, and the shoulder; *ten deep motor branches* for the recti muscles and the longissimus colli, the trapezius, the sternomastoid, the levator scapulæ and rhomboid muscles, and for the diaphragm (phrenic nerve).

Intercostal Nerves.—To the number of twelve, formed by the anterior branches of the twelve thoracic nerves, occupy

PLATE XV.


Zone of the mandibular nerve.
Zone of the lesser occipital nerve (first n. cervical posterior br.).
Zone of the ophthalmic nerve (br. of the trigeminal).
Supra-orbital nerve (br. of the maxillary).
Zone of the maxilla.
N. masticator (br. of the mandibular).
Zone of the cervical plexus.

ZONES OF CUTANEOUS SENSIBILITY FOR THE HEAD AND NECK.

the intercostal spaces, then the costal groove; they give rise to posterior, lateral and anterior branches; supply the intercostal muscles, posterior serrati, obliquus externus, obliquus internus, rectus abdominis, and the skin of the anterior and lateral regions, thoracic, abdominal and gluteal.

Zones of Cutaneous Sensibility of the Head and Trunk.

(*Plate XV.*)

The cutaneous sensibility of the **head** depends for the face and the crown on the three branches of the trigeminal nerve, and for the postero-inferior portion (the occipital region and that of the neck) on anterior and posterior branches of the first cervical nerves.

The sensibility of the face concerns the electrotherapeutist, especially on account of the frequent and obstinate "facial neuralgia," which recovers notably under continuous galvanisation with a large swab (Bergoni's electrode).

The points of emergence in the face of the terminations of the trigeminal, the supra-orbital nerve (ophthalmic branch), the infra-orbital nerve (maxillary), and the mental nerve (mandibular), facilitate the exploration of the three branches of this nerve.

The figure on Plate XV. shows the limit of the area served by them and by the cervical nerves.

The cutaneous sensibility of the **thorax** and of the **dorsal region** depends on the anterior branches of the thoracic nerves. The cutaneous area of each of them is situated a little below the points of emergence from the vertebral column, and is disposed almost parallel with the areas of the nerves which are immediately above and below them. The sensibility of the **abdominal wall** and of the **lumbar regions** depends on the last thoracic nerves and the first lumbar nerves (ilio-hypogastric and ilio-inguinal).

III.—UPPER LIMB

Muscles of the Arm.

(*Plates XVI., XVII., XVIII., XIX.*)

Deltoid.—*Origin:* lateral third of clavicle, lateral border of acromion, spine of the scapula (three fasciculi).

Insertion: above the radial groove of the humerus.

Abductor and elevator of the arm, produces in the normal state two-thirds of this movement.

Nerve: axillary (brachial plexus, common trunk with the radial).

Motor points: middle lateral portion at 4 or 5 centimetres below the acromion; anterior portion about 3 centimetres below the acromial end of the clavicle.

N.C.Con.=3·2; P.C.Con.=4·3.

Biceps.—*Origin:* short head, the coracoid process; long head, the supraglenoidal tuberosity.

Insertion: the dorsal portion of the tubercle of the radius.

Nerve: musculo-cutaneous (brachial plexus).

Motor point: middle of the muscle, a little below the deltoid.

N.C.Con.=1·2; P.C.Con.=2 (is reckoned among the most excitable muscles).

Coraco-brachialis.—*Origin:* the coracoid process.

Insertion: middle of the medial border of the shaft of the humerus.

Elevator and adductor of the arm.

Nerve: musculo-cutaneous.

Motor point: accessible with great difficulty, internal to the superior third of the biceps.

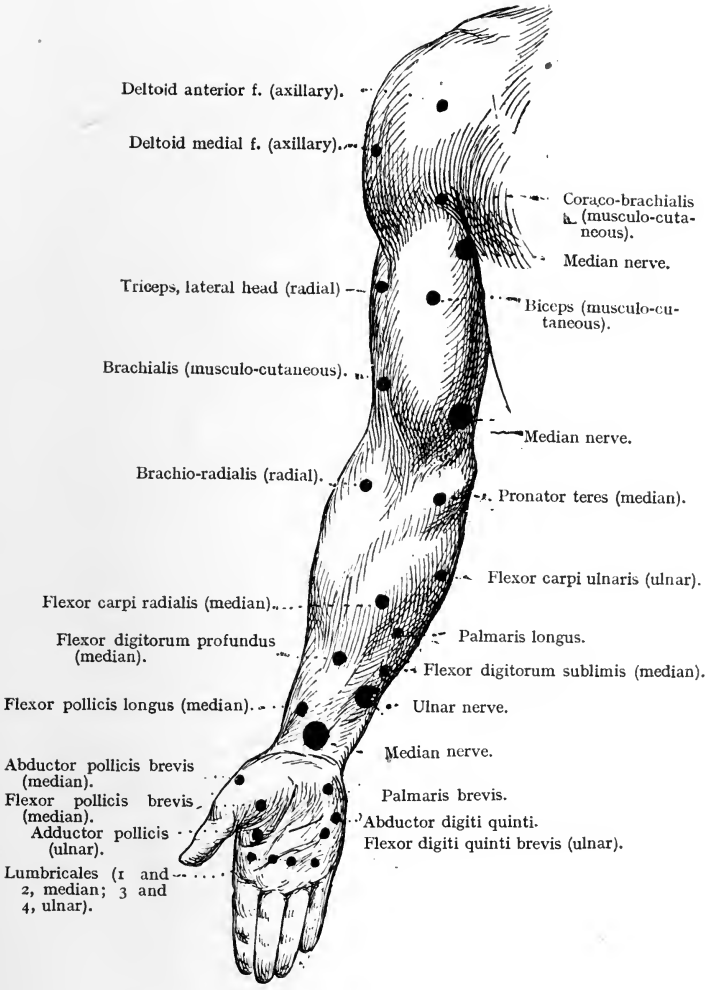
Brachialis.—*Origin:* anterior aspect of the humerus below the deltoid.

Insertion: coronoid process of the ulna.

Flexor of the forearm.

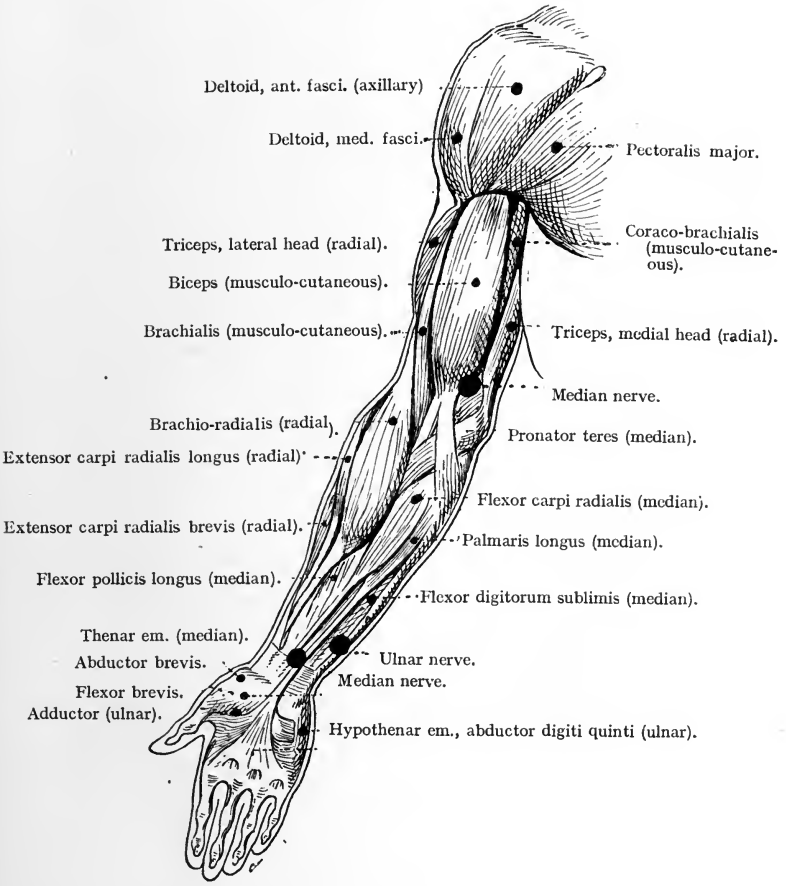
Nerve: musculo-cutaneous.

PLATE XVI.



UPPER LIMB, ANTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

PLATE XVII.



MUSCLES OF THE UPPER LIMB, ANTERIOR ASPECT: NERVE-SUPPLY AND MOTOR POINTS.

Motor points: deep muscle accessible only at its inferior portion below the medial and lateral borders of the biceps (small electrode to limit the stimulation).

N.C.Con.=1·5; P.C.Con.=2·5.

Triceps.—*Origin:* long head, infraglenoidal tuberosity; lateral and medial heads from the borders of the radial groove of the humerus.

Insertion: a single tendon fixed to the olecranon.

Extensor of the forearm.

Nerve: radial.

Motor points: lateral head, inferior third of the lateral aspect of the arm; medial head, inferior third of the medial aspect of the arm.

N.C.Con.=3; P.C.Con.=5·8.

Principal Anterior and Medial Muscles of the Forearm and Hand.

(*Plates XVI. and XVII.*)

Flexor Carpi Ulnaris.—*Origin:* medial epicondyle and medial border of the olecranon.

Insertion: pisiform bone.

Flexor and adductor of the hand.

Nerve: ulnar.

Motor point: middle third of the medial aspect of the forearm.

N.C.Con.=3; P.C.Con.=4.

Pronator Teres.—*Origin:* medial epicondylic ridge of the humerus and coronoid process.

Insertion: middle third of lateral aspect of the radius.

Pronator and flexor of the forearm.

Nerve: median.

Motor points: at 2 or 3 centimetres in front of and below the medial epicondyle.

N.C.Con.=4; P.C.Con.=5·5.

Flexor Carpi Radialis.—*Origin:* medial epicondyle.

Insertion: base of the second metacarpal.

Flexor of the hand and forearm.

Nerve : median.

Motor point : middle of the anterior aspect of the forearm.

N.C.Con.=3·5; P.C.Con.=4·5.

Flexor Digitorum Sublimis.—*Origin :* medial epicondyle, coronoid process, and middle third of radius.

Insertion : second phalanx of the last four fingers. Flexes the second phalanx, then the fingers, the hand, and the forearm.

Nerve : median.

Motor point : 3 or 4 centimetres lower than the flexor carpi radialis.

N.C.Con.=4·3; P.C.Con.=5·4.

Flexor Digitorum Profundus.—Situated below the foregoing, inaccessible.

Nerves : median for the index and middle fingers, ulnar for the ring and little fingers.

Flexor Pollicis Longus.—*Origin :* anterior aspect of the radius and interosseous membrane.

Insertion : last phalanx of the thumb.

Flexes the last, then the first phalanx of the thumb.

Nerve : median.

Motor point : 4 or 5 centimetres above the bend of the wrist, groove of the pulse.

N.C.Con.=4·5 ; P.C.Con.=5·5.

Principal Lateral and Posterior Muscles of the Forearm.

(*Plates XVI., XVII., XVIII., and XIX.*)

Brachioradialis.—*Origin :* lateral border of the humerus above the lateral epicondyle.

Insertion : styloid process of the radius.

Flexor, abductor, and supinator of the forearm.

Nerve : radial (branch detached before bifurcation).

Motor point : lateral superior third, anterior aspect of the forearm.

N.C.Con.=4·5; P.C.Con.=5·5.

Extensor Carpi Radialis Longus.—*Origin :* lateral border of the humerus, below the foregoing.

Insertion : base of the second metacarpal bone, dorsal aspect.

Extensor and abductor of the hand.

Nerve : radial (before its bifurcation).

Motor point : behind and a little above the lateral epicondyle.

N.C.Con.=4; P.C.Con.=5.

Extensor Carpi Radialis Brevis.—*Origin :* lateral epicondyle.

Insertion : base of the third metacarpal bone, dorsal aspect.

Extensor of the hand.

Nerve : radial, posterior branch.

Motor point : postero-lateral border of the arm at 3 or 4 centimetres below the lateral epicondyle.

N.C.Con.=4; P.C.Con.=5.

Extensor Digitorum Communis.—*Origin :* lateral epicondyle, posterior aspect.

Insertion : second and third phalanges of the four medial fingers.

Extensor of the fingers, then of the hand.

Nerve : dorsal interosseous nerve.

Motor point : proximal third of the posterior aspect of the forearm, near the lateral border.

N.C.Con.=4·3 ; P.C.Con.=6.

Extensor Digiti Quinti Proprius.—*Origin :* lateral epicondyle, posterior aspect.

Insertion : second and third phalanges of the little finger.

Extensor of the little finger.

Nerve : dorsal interosseous nerve.

Motor point : below and a little lateral to the extensor digitorum communis.

N.C.Con.=4; P.C.Con.=5·5.

Abductor Pollicis Longus, Extensor Pollicis Brevis, and Extensor Pollicis Longus.—These muscles, the tendons of which mark the limits of the anatomical "snuff-box," deeply situated on the posterior aspect of the forearm, become accessible at the inferior portion; they are all supplied by the radial.

Motor points : ranged in steps on the distal third of the postero-lateral aspect of the forearm.

N.C.Con.=4; P.C.Con.=4·5.

Extensor Carpi Ulnaris.—*Origin :* lateral epicondyle.

Insertion : base of the fifth metacarpal bone, dorsal aspect.

Extensor and adductor of the hand.

Nerve : dorsal interosseous nerve.

Motor point : proximal third, middle line of dorsal aspect of the forearm.

N.C.Con.=3·5; P.C.Con.=4·5.

Principal Muscles of the Hand.

(Plates XVI., XVII., XVIII., and XIX.)

Thenar Eminence.—Abductor pollicis brevis, the outermost and the most superficial, goes from the navicular bone and the annular ligament to the radial side of the first phalanx.

Nerve : median.

Motor point : middle of the anterior aspect of the first metacarpal bone.

N.C.Con.=2·8; P.C.Con.=5·1.

Flexor brevis, on the two-thirds covered by the abductor, accessible within the latter, goes from the greater multangular bone and the annular ligament to the radial side of the base of the first phalanx of the thumb; flexes the first phalanx.

Nerve : median.

Motor point : inside and in front of the muscle.

Adductor.—*Origin :* greater and lesser multangular bones, capitate bone, and bases of the second, third, and fourth metacarpal bones.

Insertion : medial side of the base of the first phalanx of the thumb.

Nerve : ulnar.

Motor point : base of the first interosseous space.

Opponens pollicis, deep, inaccessible.

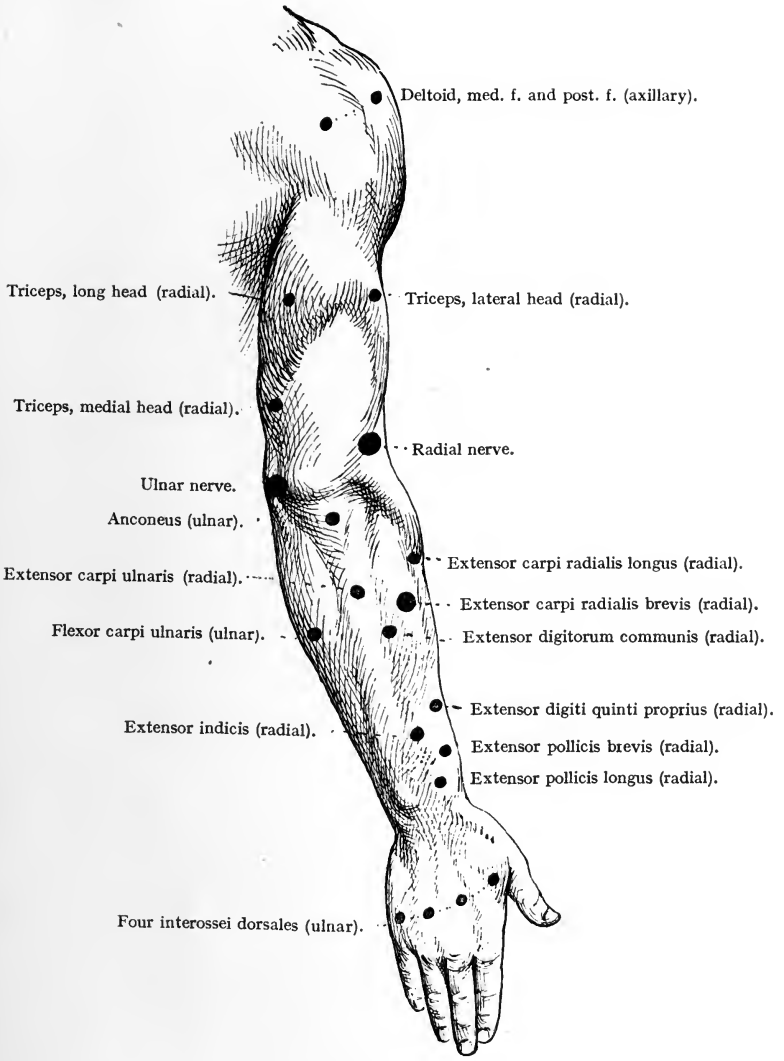
Hypothenar Eminence.—Abductor digiti quinti, goes from the pisiform bone to the medial side of the base of the first phalanx of the little finger.

Nerve : ulnar.

Motor point : middle of the medial border of the hypothenar eminence.

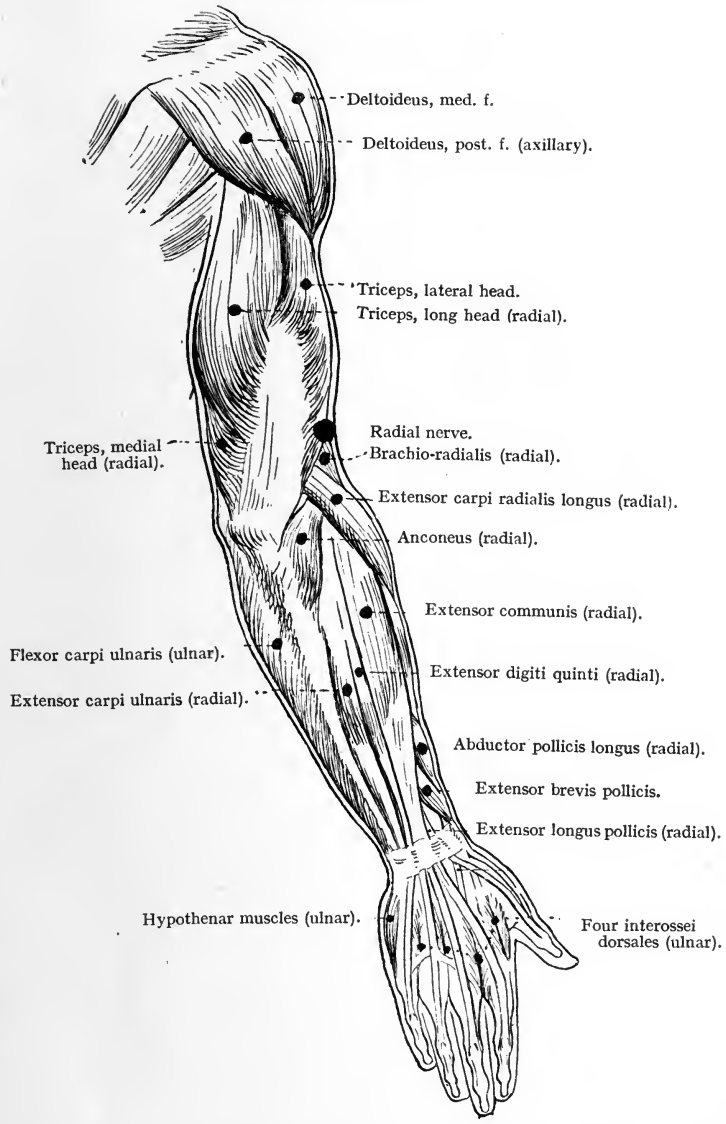
N.C.Con.=4; P.C.Con.=5.

PLATE XVIII.



UPPER LIMB, POSTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

PLATE XIX.



MUSCLES OF THE UPPER LIMB, POSTERIOR ASPECT: NERVE-SUPPLY AND MOTOR POINTS.

Flexor brevis, goes from the os hamatum to the first phalanx.

Nerve : ulnar.

Motor point : in front of and within the abductor digiti quinti.

Opponens, deep, inaccessible.

The Four Lumbricales.—They arise from the flexor tendons, and join the extensor tendons of the second, third, fourth and fifth fingers.

Motor points : distal third of the interosseous palmar spaces.

The **Interossei Volares** are inaccessible.

Interossei Dorsales.—Four muscles arise from the lateral aspects of the metacarpal bones, and go to the base of the first phalanx and to the extensor tendons of the second, third, and fourth fingers. Spread the fingers.

Nerve : ulnar (deep branch).

Motor points : middle of the spaces between the metacarpal bones, dorsal aspect.

N.C.Con.=4; P.C.Con.=5.

NERVES OF THE UPPER LIMB

Brachial Plexus.

(*Plates XX., XXI., XXII.*)

Formed by the anterior rami of the fifth, sixth, seventh, and eighth cervical nerves, and the greater part of the thoracic nerve, which unite and cross each other as is shown in Plate XXI., the brachial plexus supplies all the motor and sensory nerves of the upper limb and of its thoracic attachments. Descending obliquely from the neck towards the shoulder between the two scaleni, it passes below the clavicle, and reaches the axilla behind the pectoralis major.

Immediately above the clavicle, between the lateral border of the cleido-mastoid and the anterior border of the trapezius, the plexus (the five roots of which join into two principal trunks, whichare divided soon afterwards into its terminal branches) rests on the first rib, and is accessible directly and

completely. The electric swab applied to this region (*Erb's point*) stimulates the whole of the plexus there, and provokes the contraction of all the muscles of the arm.

N.C.Con.=2·7; P.C.Con.=5.

The brachial plexus gives off eleven collateral motor branches for the muscles of the shoulder (major and minor pectorales, levator scapulæ, rhomboideus, supra- and infra-spinatus, subscapularis, serratus anterior teres major, and latissimus dorsi.) Also one collateral sensory branch, the accessory of the medial cutaneous nerve of the forearm, which supplies the skin of the medial aspect of the forearm, and six terminal branches: axillary, musculo-cutaneous, radial, median, ulnar, and medial cutaneous nerve of the arm.

Axillary Nerve.—Originating below the pectoralis major from a nerve trunk which is common with the radial (fibres coming from the fifth and sixth cervical nerves), it proceeds downwards, backwards, and outwards, below the deltoid, over which it is distributed after having wound round the surgical neck of the humerus.

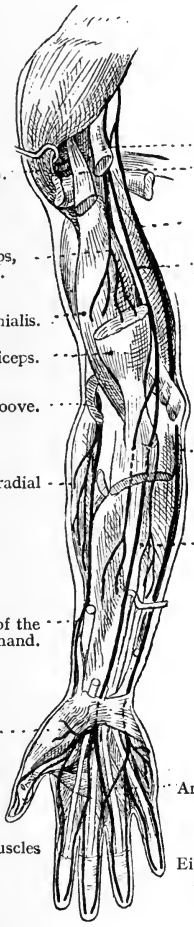
Musculo-cutaneous Nerve.—Originating from the lateral root of the median (fibres of the fifth and sixth cervical nerves), it descends near this nerve to below the tendon of the pectoralis major, traverses in this region the coraco-brachialis, supplies this muscle as well as the biceps and the brachialis, becomes superficial in the bend of the elbow, and terminates in the skin of the lateral region of the forearm.

Median Nerve.—The largest of all, it originates near the inferior border of the pectoralis major by two roots—one in common with the musculo-cutaneous, the other in common with the ulnar; comprises fibres of the sixth, seventh, and eighth cervical nerves, and the first thoracic nerve; descends below the medial border of the biceps with the brachial artery as far as the bend of the elbow, then occupies the middle of the anterior aspect of the forearm below the flexor digitorum sublimis, passes to the wrist in the groove of the carpus, and terminates by numerous branches in the palm of the hand.

The *median supplies :* in the arm, nothing.

In the forearm the muscles, pronator teres, flexor carpi

PLATE XX.



Short head of biceps.

Long head of biceps.

N. axillary (under the deltoid).

N. ulnar on the medial head of triceps.

N. musculo-cutaneous (biceps, brachialis, and coraco-brachialis).

N. median on the brachialis.

Brachialis.

Biceps.

N. radial emerging from the groove.

N. ulnar coming out of the groove between the med. epicondyle and the olecranon, follows the medial border of the forearm.

N. radial: its branches for the radial extensors and brachio-radialis.

N. median: under the flexor carp radialis, between the flexor pollicis and flexor communis.

N. median: its branches for the palmar muscles and flexors of the fingers.

Terminal branch: anterior sensory of the radial passing to the back of the hand.

Termination of the ulnar supplying the hypothenar muscles, interossei, and adductor pollicis.

Branch of the median for the thenar muscles.

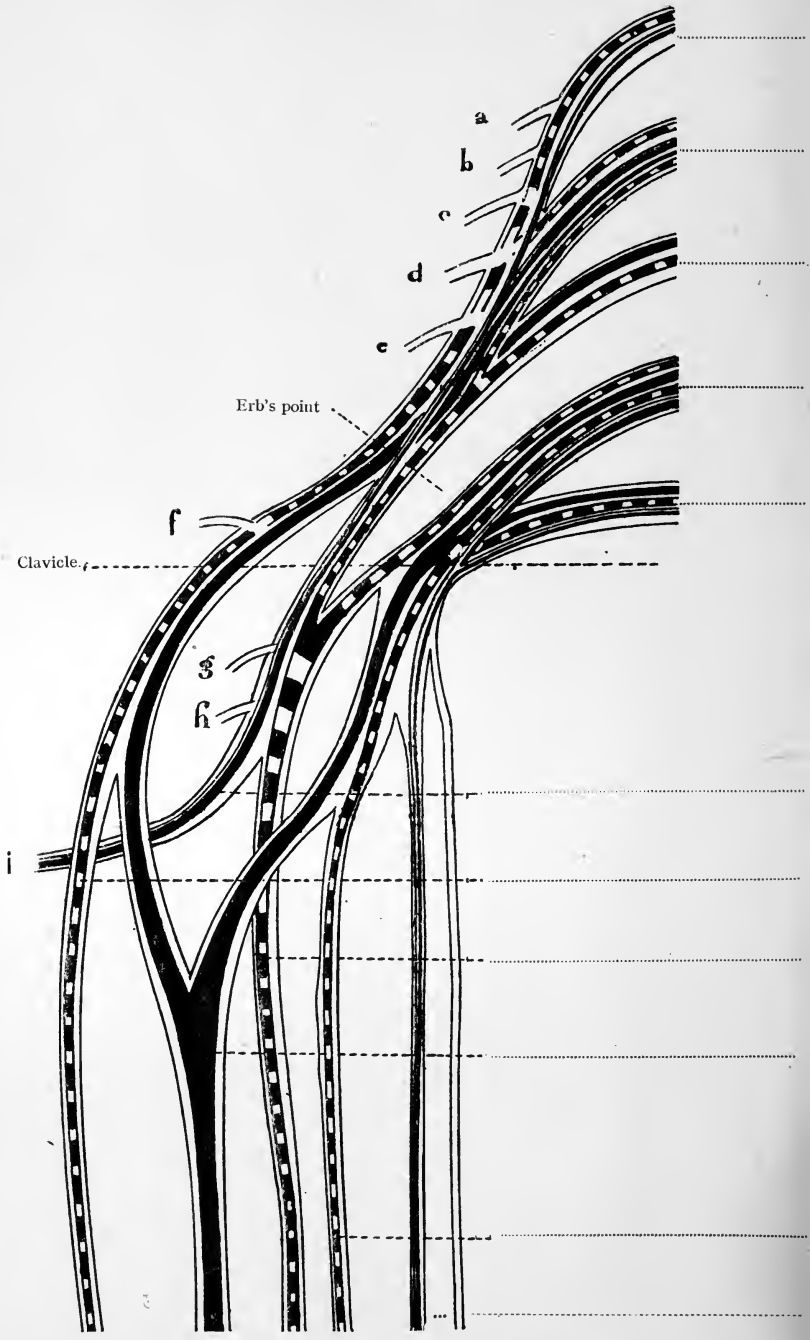
Anastomosis of the median and the ulnar.

The first seven collateral palmar muscles supplied by the median.

Eighth, ninth, and tenth collateral palmar muscles supplied by the ulnar.

NERVES OF THE UPPER LIMB, ANTERIOR ASPECT.

PLATE XXI.



BRACHIAL PLEXUS. (Plan in part after Testut.)

PLATE XXI.—*Continued*

Origin.

Fifth cervical { musculo-cutaneous. / axillary.

Sixth cervical { musculo-cutaneous. / axillary. / radial. / median.

Seventh cervical { radial. / median.

Eighth cervical { radial. / median. / ulnar. / cutaneous medialis.

First thoracic { median. / ulnar / cutaneous medialis.

Distribution.

Accessory branches: *a*, nerve of the rhomboid; *b*, nerve of the levator scapulæ; *c*, nerve of the serratus anterior; *d*, nerve of the supra- and infra-spinatus; *e*, nerve of the subscapularis; *f*, nerve of the pectoralis major; *g*, nerve of the latissimus dorsi: *h*, nerve of the teres major; *i*, accessory of the cutaneous medialis.

Axillary (fifth and sixth cervicals), deltoid and teres minor. Sensibility of the shoulder.

Musculo-cutaneous (fifth and sixth cervicals), coraco-brachialis, biceps, brachialis. Sensibility of the lateral region of the forearm.

Radial (fifth, seventh, and eighth cervicals), triceps, brachio-radialis, supinator, extensors. Sensibility of the posterior aspect of the arm, forearm, and hand.
Extensor and supinator nerve.

Median (sixth, seventh, and eighth cervicals, and first thoracic), all the anterior muscles of the forearm, except the flexor carpi ulnaris and two medial fasciculi of the flexor profundus; first and second lumbricales, thenar muscles, except the adductor pollicis. Sensibility of the thenar, the palm, and the first three fingers, and lateral half of the fourth.
Flexor and pronator nerve.

Ulnar (eighth cervical and first thoracic), flexor carpi ulnaris, two medial fasciculi of the flexor profundus, adductor pollicis, interossei, third and fourth lumbricales, hypothenar muscles. Sensibility of the medial part of the back of the hand, the hypothenar muscles, the little finger, and medial half of the fourth finger.

Medial cutaneous (eighth cervical and first thoracic), no motor branch. Sensibility of the medial region of the arm and forearm.

radialis, palmaris longus, flexor pollicis, and the superficial and deep flexors of the fingers (except the flexor digitorum profundus, where the fourth and fifth fingers are supplied by the ulnar).

In the wrist: the pronator quadratus.

In the hand: the thenar muscles (except the adductor pollicis and the two lateral lumbricales). As sensory branches it supplies the first seven collateral palmar nerves which serve the lateral two-thirds of the palm of the hand (thumb, index, middle, and lateral portion of the ring finger), and the dorsal aspect of the second and third phalanges of the second and third fingers.

To sum up, the median is *the flexor and pronator nerve*, supplying the greater number of the anterior muscles of the forearm and the first three fingers.

Points of stimulation : the median can be stimulated directly a little above the elbow and on the middle line at the wrist.

N.C.Con.=3·3; P.C.Con.=4·5.

Ulnar Nerve.—It originates in the axilla from the medial root of the median (fibres of the eighth cervical nerve and first thoracic), descends to the arm with the brachial artery a little behind the median, passes behind in the groove on the medial epicondyle, winds round the ulna at its middle third, then descends on the anterior aspect below the flexor carpi ulnaris, the lateral border of the tendon of which it accompanies near the wrist, terminates at the hand in two branches: one superficial, cutaneous; the other, deep, muscular.

The *ulnar supplies :* in the arm, nothing.

In the forearm: the flexor carpi ulnaris and the medial fasciculi (ring and little finger) of the flexor communis profundus.

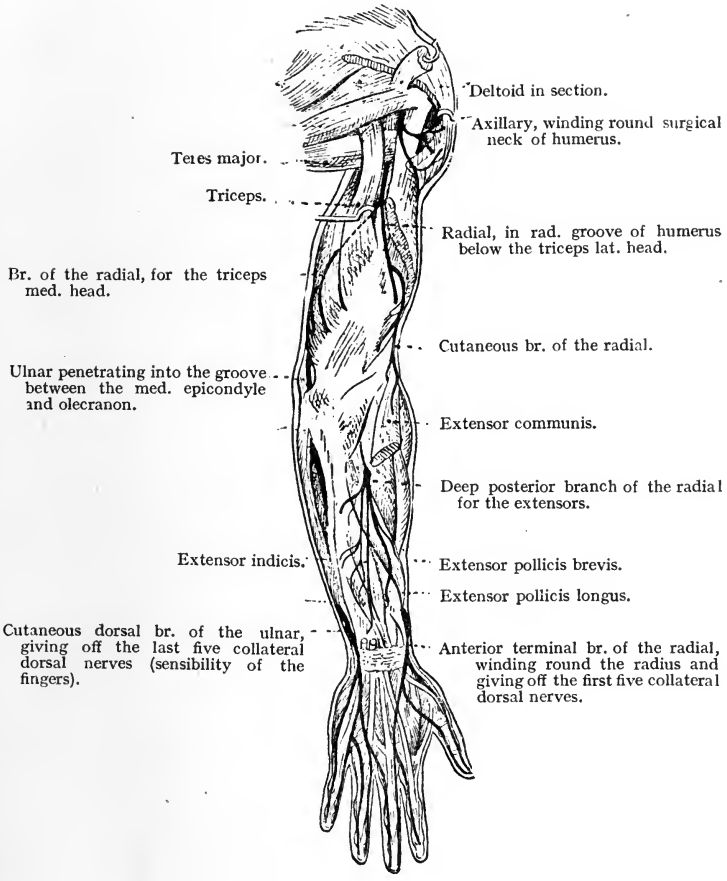
In the hand: the hypothenar muscles, interossei, adductor pollicis, and third and fourth lumbricales.

It supplies the last two collateral dorsal and the last three collateral palmar muscles, and a complementary branch for the flexor pollicis brevis.

Points of stimulation : The ulnar is easily accessible in the groove between the medial epicondyle and the olecranon, and at the anterior aspect of the wrist, a little above the fold in flexion, on the lateral side of the pisiform bone.

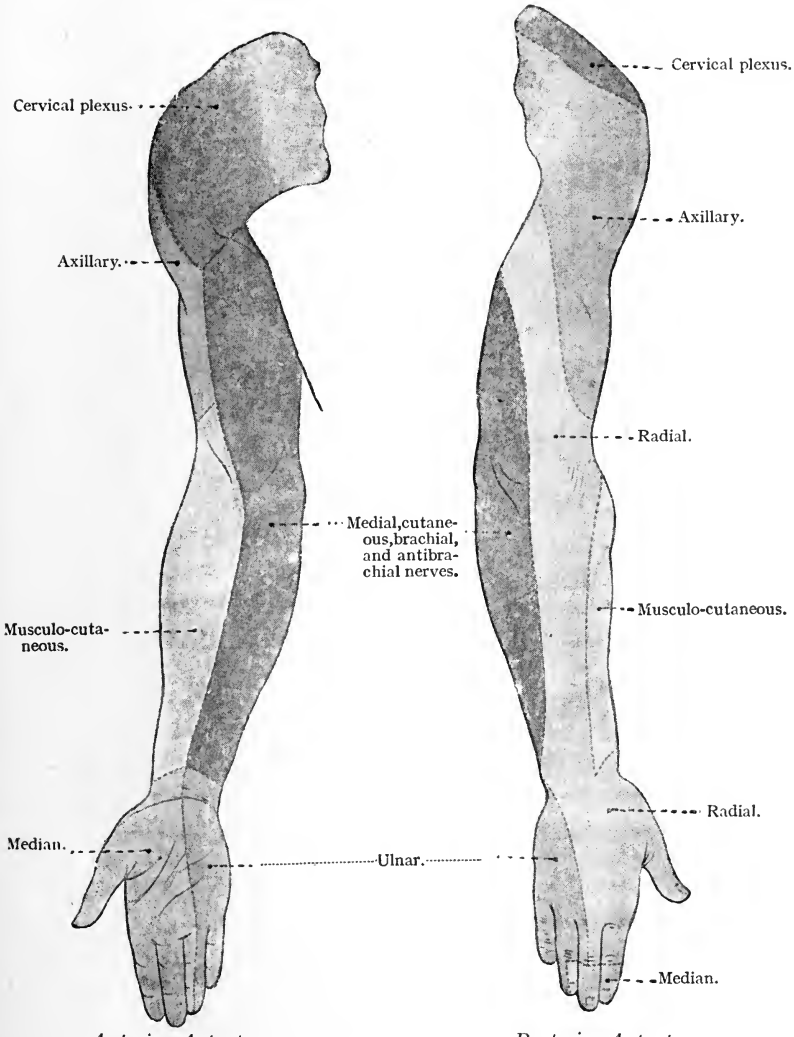
N.C.Con.=2·5; P.C.Con.=3·7.

PLATE XXII.


Deltoid in section.
Axillary, winding round surgical neck of humerus.
Teres major.
Triceps.
Radial, in rad. groove of humerus below the triceps lat. head.
Br. of the radial, for the triceps med. head.
Cutaneous br. of the radial.
Ulnar penetrating into the groove between the med. epicondyle and olecranon.
Extensor communis.
Deep posterior branch of the radial for the extensors.
Extensor indicis.
Extensor pollicis brevis.
Extensor pollicis longus.
Cutaneous dorsal br. of the ulnar, giving off the last five collateral dorsal nerves (sensibility of the fingers).
Anterior terminal br. of the radial, winding round the radius and giving off the first five collateral dorsal nerves.

NERVES OF THE UPPER LIMB, POSTERIOR ASPECT.

PLATE XXIII.



ZONES OF CUTANEOUS SENSIBILITY OF THE UPPER LIMB.

Medial Cutaneous Nerve of the Arm and the Forearm.—Sensory, it originates from the common root of the median and the ulnar, descends with this last, the proximal third of the arm, then becomes subcutaneous, and divides at the region of the medial epicondyle into two anterior and posterior branches. With its accessory, it supplies the skin of the medial aspect (anterior and posterior) of the arm and forearm.

Radial Nerve.—Originating from a common trunk with the axillary (fibres of the fifth, sixth, and seventh cervical nerves), it proceeds obliquely downwards, backwards, and outwards, follows the radial groove in contact with the humerus, with the deep brachial artery, to below the triceps, the three parts of which it supplies. A little above the lateral epicondyle it divides into two branches:

One anterior, slender, sensory, which descends with the brachioradialis, then with the radial artery, winds round the epiphysis of the radial, and terminates giving off the first three collateral dorsal nerves.

One posterior, more important, motor, which supplies first a branch to the extensor carpi radialis brevis, traverses and supplies the supinator muscle, and is distributed among the posterior muscles of the forearm—*i.e.*, extensor digitorum communis, extensor digiti quinti proprius, extensor indicis, extensor pollicis, adductor pollicis longus, extensor carpi ulnaris.

Immediately before its bifurcation, the radial sends two important branches to the brachioradialis and the extensor carpi radialis longus.

The radial is the supinator and extensor nerve.

Point of stimulation : on the postero-lateral border of the arm between the lateral head of the triceps and the brachialis, at three or four fingers' breadths above the elbow.

N.C.Con.=3·5; P.C.Con.=5.

Cutaneous Sensibility of the Upper Limb

(*Plate XXIII.*)

Shoulder.—Anterior aspect: cervical plexus. Posterior aspect: axillary.

Arm.—Anterior aspect: lateral portion, axillary; middle

portion, medial cutaneous; medial portion, accessory. Posterior aspect: lateral portion, axillary; middle portion, radial; medial portion, accessory.

Forearm.—Anterior aspect: lateral portion, musculo-cutaneous; middle portion, medial cutaneous of the forearm. Posterior aspect: lateral portion, musculo-cutaneous; middle portion, radial; medial portion, medial cutaneous of the forearm.

Hand.—Volar aspect: lateral two-thirds, median; medial third, ulnar. Dorsal aspect: lateral half, radial; medial half, ulnar. Index, middle, and lateral half of ring finger: median.

IV.—LOWER LIMB.

Principal Anterior and Medial Muscles of the Thigh.

(*Plates XXIV. and XXV.*)

Sartorius.—*Origin :* superior anterior iliac spine.

Insertion : medial aspect of the proximal extremity of the tibia (" patte d'oie ").

Flexor and adductor of the thigh.

Nerve-supply : musculo-cutaneous branch of the femoral.

Motor point : about 10 centimetres below the fold of the groin on the middle line.

N.C.Con.=4·5; P.C.Con.=9.

Gracilis.—*Origin :* symphysis pubis.

Insertion : medial aspect of the proximal extremity of the tibia (" patte d'oie ").

Adductor of the thigh.

Nerve-supply : obturator and femoral.

Motor point : medial portion of the thigh about 10 centimetres below the pubis.

N.C.Con.=3; P.C.Con.=4.

Quadriceps.—It comprises a deep and inaccessible muscle: the femoral and three superficial ones—the rectus femoris, vastus medialis, and vastus lateralis.

Origin : rectus femoris: superior anterior iliac spine. Vastus lateralis: trochanter major and linea aspera (lateral lip). Vastus medialis: medial lip of the linea aspera.

Insertion : common on the patella, and by the patellar tendon on the tibia.

Extensor of the leg, and flexor of the thigh.

Nerve-supply : femoral.

Motor points : rectus femoral, middle third of muscle, middle line; vastus lateralis, about 20 centimetres above the patella; vastus medialis at 10 centimetres.

N.C.Con.=7·5; P.C.Con.=12.

Pectineus.—*Origin :* pubis.

Insertion : femur, below the trochanter minor.

Adductor of the thigh.

Nerve-supply : femoral and obturator (lumbar plexus).

Motor points : about 10 centimetres below the fold of the groin, medial one-third.

N.C.Con.=4; P.C.Con.=8.

Adductors.—Three muscles: first, or longus, situated high up and superficial, accessible only between the pectineus and the gracilis; second, or brevis; third, or magnus, deeply situated between the anterior and posterior muscles of the thigh.

Origin : ischium pubis.

Insertion : linea aspera femoris in all its length.

Nerve-supply : obturator for the longus, obturator and femoral for the brevis, obturator and sciatic for the magnus.

Motor point : on the longus about 15 centimetres below the fold of the groin, within the pectineus.

Anterior and Lateral Muscles of the Leg and Foot.

(*Plates XXIV. and XXV.*)

Tibialis Anterior.—*Origin :* proximal two-thirds of the lateral aspect of the tibia.

Insertion : first cuneiform and first metatarsal bones.

Flexor and adductor of the foot.

Nerve : common peroneal (deep branch).

Motor point : proximal third of the leg about 2 centimetres on the lateral side of the crest of the tibia.

N.C.Con.=8; P.C.Con.=10·5.

Extensor Digitorum Longus.—*Origin :* superior portion of the medial aspect of the fibula.

Insertion : second and third phalanges of the toes.

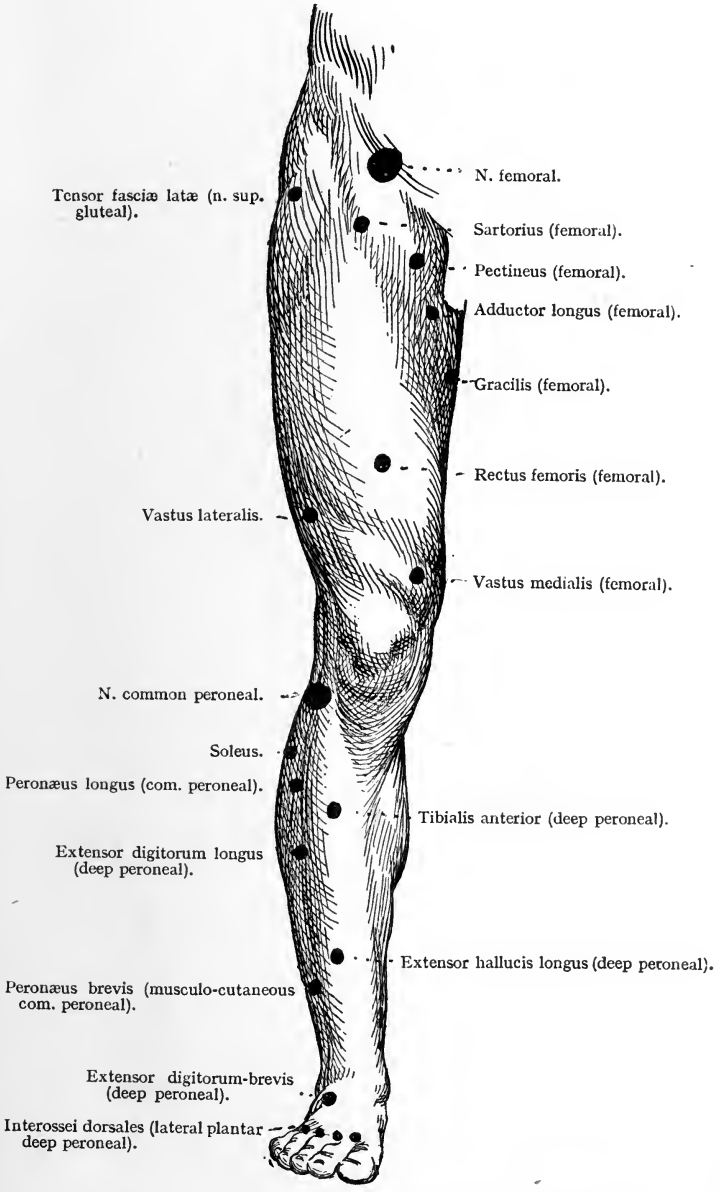
Flexor of the foot. Extensor of the toes.

Nerve : deep peroneal.

Motor point : middle third of the leg about 4 centimetres on the lateral side of the crest of the tibia.

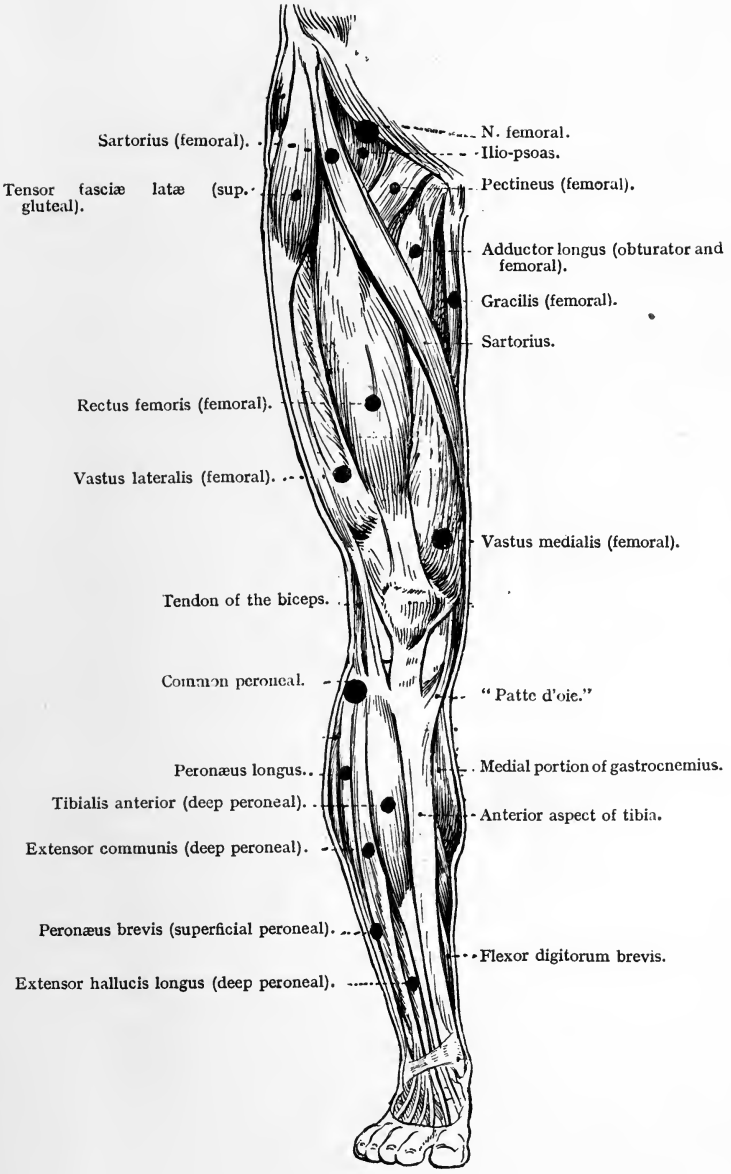
N.C.Con.=8; P.C.Con.=10.

PLATE XXIV.



LOWER LIMB, ANTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

PLATE XXV.



MUSCLES OF THE LOWER LIMB, ANTERIOR ASPECT: NERVE-SUPPLY AND MOTOR POINTS.

Extensor Hallucis Longus.—*Origin :* middle portion of the medial aspect of the fibula.

Insertion : first and second phalanges of the great toe.

Flexor and adductor of the foot. Extensor of the great toe.

Nerve : deep peroneal.

Motor point : distal third of the leg about 2 centimetres on the lateral side of the crest of the tibia.

N.C.Con.=8; P.C.Con.=10.

Peronæus Longus.—*Origin :* proximal third of the lateral aspect of the fibula.

Insertion : distal aspect of the lateral tubercle of the first metatarsal bone by a long tendon which, bending behind the lateral malleolus, traverses the sole of the foot obliquely.

Extensor and abductor of the foot. Tensor of the plantar arch.

Nerve : superficial peroneal branch of the common peroneal.

Motor point : proximal third of the leg about 4 centimetres on the lateral side of the tibia.

N.C.Con.=8; P.C.Con.=11.

Peronæus Brevis.—*Origin :* fibula, middle third, lateral aspect.

Insertion : Tuberosity and dorsal surface of the base of the fifth metatarsal.

Abductor and extensor of the foot.

Nerve : superficial peroneal.

Motor point : distal third of the leg at 4 centimetres on the lateral side of the tibial crest.

N.C.Con.=8; P.C.Con.=11.

Extensor Digitorum Brevis.—*Origin :* superior aspect of the calcaneus and talo-calcaneal hollow.

Insertion : by small tendons attached to the extensor digitorum longus at the base of the first phalanges of the toes.

Extensor and adductor of the toes.

Nerve : deep peroneal.

Motor point : dorsum of the foot in front of the lateral malleolus.

N.C.Con.=4·5; P.C.Con.=7.

Interossei Dorsales.—Four small muscles which go from the lateral aspects of the metatarsal bones to the base of the first

phalanges of the second, third, and fourth toes. The first is the adductor of the second toe; the second, third, and fourth are abductors of the second, third, and fourth toes.

Nerve : lateral plantar (tibial).

Motor points : Anterior third of the interosseus spaces.

N.C.Con.=6; P.C.Con.=8.

Principal Posterior Muscles of the Thigh.

(*Plates XXVI. and XXVII.*)

Glutæus Maximus.—*Origin :* sacrum, coccyx, and posterior curved line of the iliac bone.

Insertion : femur from the linea aspera to the trochanter major.

Extensor of the thigh and the foot.

Nerve : inferior gluteal.

Motor point : middle of the buttock.

N.C.Con.=8; P.C.Con.=13·5.

Glutæus Medius.—*Origin :* superior portion of the lateral iliac fossa.

Insertion : apex of the trochanter major.

Abductor of the thigh, arrector of the pelvis.

Nerve : superior gluteal (sacral plexus).

Motor point : about 5 centimetres below the iliac crest, lateral third.

N.C.Con.=8; P.C.Con.=13·5.

Tensor Fasciæ Latæ.—*Origin :* behind the superior anterior iliac spine.

Insertion : aponeurosis of the thigh, middle third.

Abductor of the thigh.

Nerve : superior gluteal (sacral plexus).

Motor point : proximal third of the thigh, lateral aspect.

N.C.Con.=4; P.C.Con.=6·5.

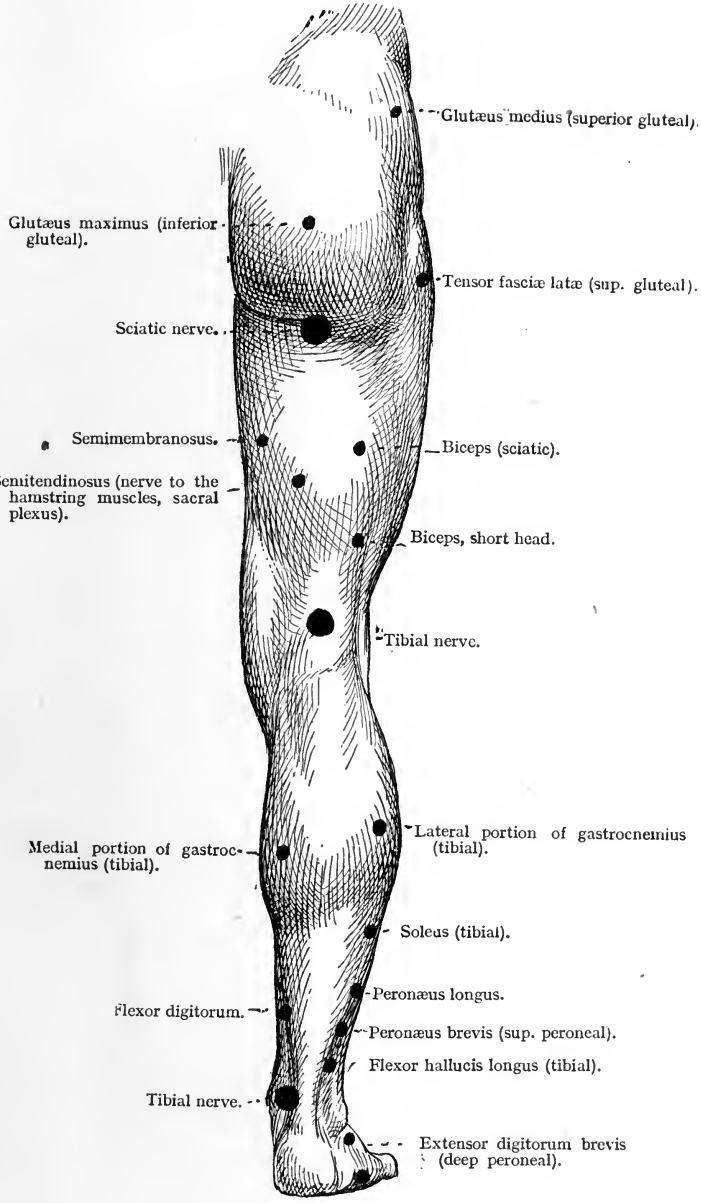
Biceps Femoris.—*Origin :* ischium and lateral lip of the linea aspera femoris.

Insertion : by a long single tendon on the head of the fibula.

Extensor of the thigh. Flexor of the leg.

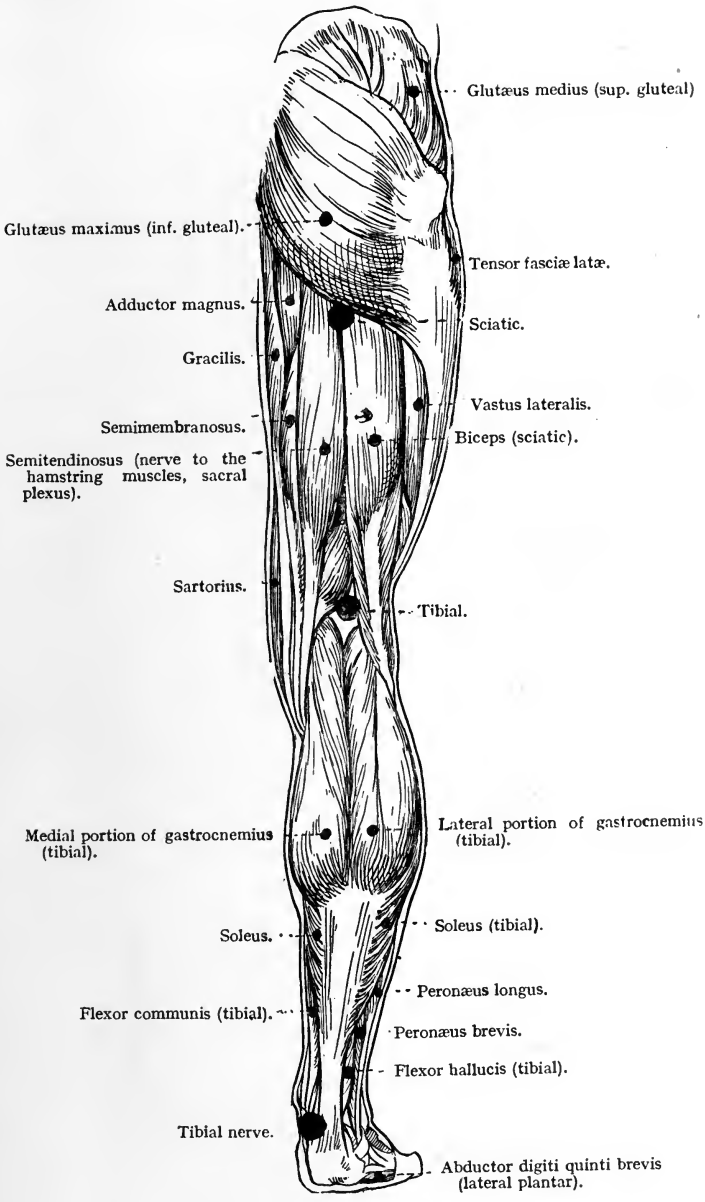
Nerve : sciatic.

PLATE XXVI.



LOWER LIMB, POSTERIOR ASPECT: OUTLINES, PROMINENCES, AND MOTOR POINTS OF NERVES AND MUSCLES.

PLATE XXVII.



MUSCLES OF THE LOWER LIMB, POSTERIOR ASPECT: NERVE-SUPPLY AND MOTOR POINTS.

Motor point : postero-lateral region of the thigh, middle third.

N.C.Con.=11·5; P.C.Con.=16.

Semimembranosus.—*Origin :* ischium by a long flat membranous tendon.

Insertion : medial tuberosity of the tibia.

Extensor of the thigh. Flexor of the leg.

Nerve : sciatic.

Motor point : postero-medial border of the thigh, middle third.

N.C.Con.=12; P.C.Con.=16.

Semitendinosus.—Within the semimembranosus.

Origin : ischium.

Insertion : by a long tendon on the supero-medial side of the proximal extremity of the tibia (" patte d'oie ").

Extensor of the thigh. Flexor of the leg.

Nerve : sciatic.

Motor point : postero-medial region of the thigh, a little below and lateral to the semimembranosus.

N.C.Con.=12 ; P.C.Con.=17.

Principal Posterior Muscles of the Leg and Foot.

(*Plates XXVI. and XXVII.*)

Gastrocnemius.—*Origin :* posterior portion of the medial and lateral condyles of the femur.

Insertion: joined with the soleus, it forms the tendo Achillis inserted in the calcaneus.

Extensor of the foot on the leg.

Nerve : branches of the tibial.

Motor points : proximal third of the calf of the leg.

N.C.Con.=7·5; P.C.Con.=11.

Soleus.—*Origin :* posterior aspect of the tibia and head of the fibula, same action and nerve-supply as the gastrocnemius, lies on each side of the latter, can be stimulated on the borders of the gastrocnemius, middle third.

N.C.Con.=9; P.C.Con.=13.

Flexor Digitorum Longus.—Deep, inaccessible, except on the medial border of the distal third.

Origin : posterior aspect of the tibia.

Insertion : by a long tendon which glides behind the medial malleolus, and is subdivided on the sole of the foot into four terminal tendons fixed to the three phalanges of the second, third, fourth, and fifth toes.

Nerve : tibial.

Motor point : postero-medial border of the leg, distal third.

N.C.Con.=9; P.C.Con.=12·5.

Flexor Hallucis Longus.—*Origin :* posterior aspect of the fibula and the interosseous ligament.

Insertion : by a long tendon passing behind the medial malleolus, and fixed to the last phalanx of the great toe.

Nerve : tibial.

Motor point : lateral border of the tendo Achillis about 5 centimetres above the malleolus.

N.C.Con.=9; P.C.Con.=13.

Tibialis Posterior.—*Origin :* postero-medial aspect of the fibula.

Insertion : tubercle of the navicular bone and the plantar aspects of the bases of the three cuneiforms.

Extensor of the foot. Tensor of the plantar arch.

Nerve : tibial.

Muscle : deep, inaccessible.

Plantar Muscles.

Adductor Hallucis.—*Origin :* medial process of the tuberosity of the calcaneus.

Insertion : first phalanx of the great toe.

Nerve : medial plantar (tibial).

Motor point : medial border of the foot, middle third.

N.C.Con.=7·5; P.C.Con.=12.

Flexor Digitorum Brevis.—*Origin :* medial process of the tuberosity of the calcaneus.

Insertion : second phalanges of the four lateral toes.

Flexor of the phalanges.

Nerve : medial plantar.

Motor point : middle of the sole of the foot.

N.C.Con.=8; P.C.Con.=12.

Abductor Digiti Quinti.—*Origin :* lateral tuberosity of the calcaneus.

Insertion : first phalanx of the little toe.

Flexor and abductor.

Nerve : lateral plantar (tibial).

Motor point : middle of the lateral border of the foot.

N.C.Con.=8; P.C.Con.=12.

Lumbricales, Flexor Hallucis Brevis, and Flexor Digiti Quinti Brevis.—Accessible at the metatarsal region of the sole of the foot.

Flexors of the first phalanx.

Nerves : lateral plantar for the flexor digiti quinti and second, third, and fourth lumbricales; medial plantar for the flexor hallucis brevis and the first lumbricale.

N.C.Con.=8; P.C.Con.=12.

Lumbar Plexus.

(*Plates XXVIII. and XXIX.*)

Formed by the anterior branches of the first four lumbar nerves in front of the quadratus lumborum, behind the psoas, which is traversed by the greater number of its branches. These last are six in number: ilio-hypogastric, ilio-inguinal, lateral cutaneous femoral, genito-femoral, obturator, and femoral.

Ilio-hypogastric and Ilio-inguinal Nerves.—Sensory and motor, they originate from the first lumbar nerve, follow the curve of the abdominal wall between the muscles transversus, obliquus externus, and obliquus internus, which they supply, as well as the rectus abdominis and the skin of the linea alba. A branch of each of them is involved in the inguinal canal, and terminates in the skin of the genital organs.

Cutaneus Femoris Lateralis Nerve.—Sensory, originating from the second lumbar nerve, it emerges from the pelvis below the superior iliac spine, and is distributed to the skin of the gluteal regions and the antero-lateral regions of the thigh.

Genito-femoral Nerve.—Sensory, same origin and much the same course as the foregoing, it gives off a genital branch for the skin of the genital organs, and a femoral branch for the skin of the region of Scarpa's triangle.

Obturator.—Especially motor, it proceeds from the second, third, and fourth lumbar nerves, traverses the psoas, descends along the medial border of this muscle, emerges below the pubis by the obturator foramen, and is divided into two principal branches, which are distributed to the muscles, obturator externus, gracilis, and the three adductor muscles.

Femoral Nerve.—It originates from the second, third, and fourth lumbar nerves, traverses the psoas, descends between the two muscles *psoas and iliacus*, which it supplies, passes below the femoral arch in Scarpa's triangle on the lateral side of the artery; in this region it is divided into numerous branches, the chief of which are:

The two branches of the **Superficial Peroneal Nerve,** *medial* and *lateral*, for the muscles *sartorius*, *pectineus*, and *adductor longus*, and the skin of the anterior portion of the thigh.

The **Nerve of the Quadriceps** for the four muscles, *rectus femoris*, *vastus lateralis*, *vastus medialis*, and *femoral*.

The **Saphenous Nerve,** sensory, which follows the femoral artery as far as the knee, then the great saphenous vein of the leg, supplying the skin of the patellar regions, the antero-medial regions of the leg, and the medial border of the foot.

Point of stimulation : the femoral nerve is accessible directly below the femoral arch on the lateral side of the artery.

N.C.Con.=5·7; P.C.Con.=9·8.

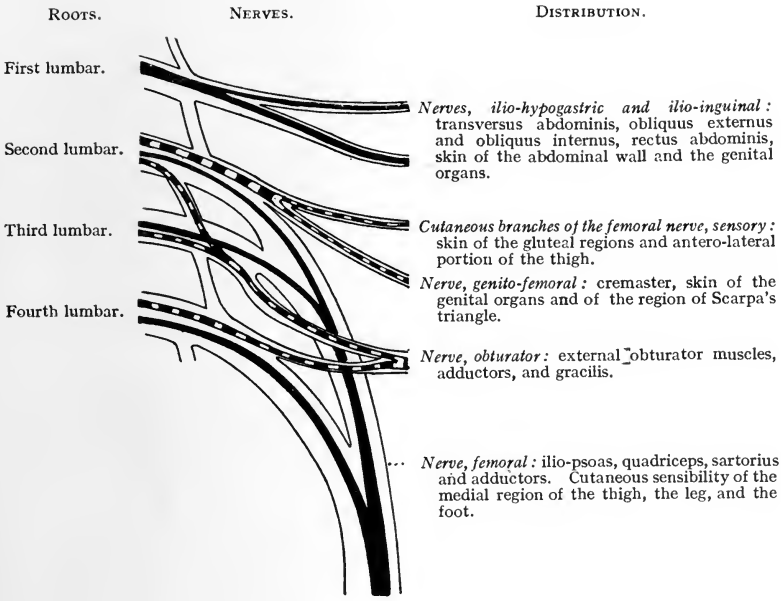
Sacral Plexus.

(*Plates XXIX., XXX., and XXXI.*)

Formed by the fifth lumbar nerve and the first, second, third, and fourth sacral nerves.

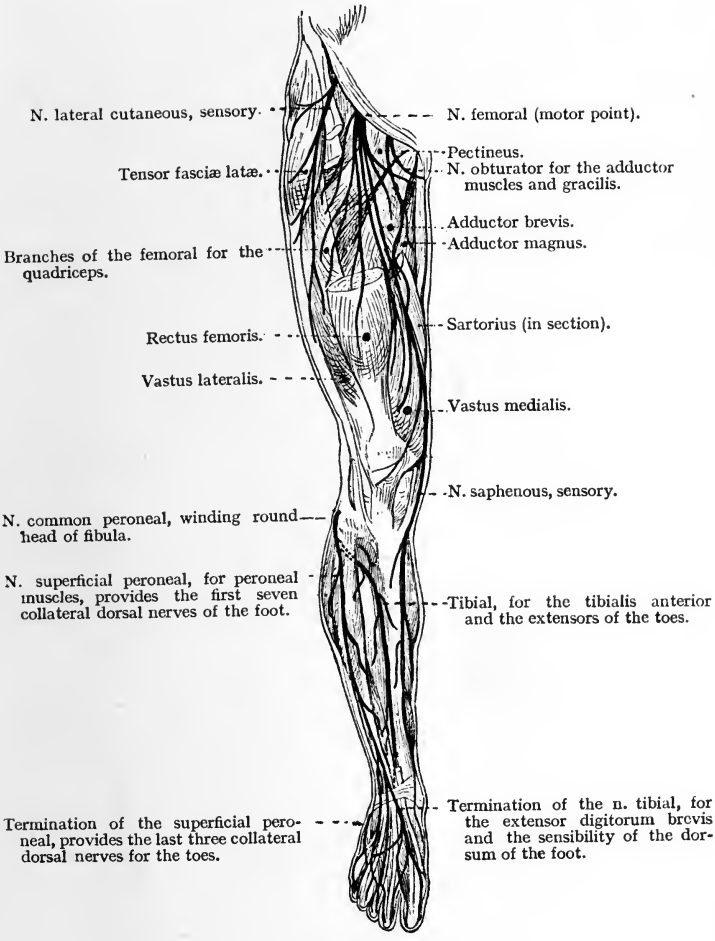
Situated in the pelvis on the anterior aspect of the sacrum, it is separated from the viscera only by an aponeurosis. It terminates in the sciatic notch, giving off the sciatic nerve, the superior gluteal, the cutaneus femoris posterior, and the

PLATE XXVIII.


Roots.
Nerves.
Distribution.
First lumbar.
Second lumbar.
Third lumbar.
Fourth lumbar.
Nerves, ilio-hypogastric and ilio-inguinal: transversus abdominis, obliquus externus and obliquus internus, rectus abdominis, skin of the abdominal wall and the genital organs.
Cutaneous branches of the femoral nerve, sensory: skin of the gluteal regions and antero-lateral portion of the thigh.
Nerve, genito-femoral: cremaster, skin of the genital organs and of the region of Scarpa's triangle.
Nerve, obturator: external obturator muscles, adductors, and gracilis.
Nerve, femoral: ilio-psoas, quadriceps, sartorius and adductors. Cutaneous sensibility of the medial region of the thigh, the leg, and the foot.

Lumbar Plexus.

PLATE XXIX.


N. lateral cutaneous, sensory.
Tensor fasciæ latæ.
Branches of the femoral for the quadriceps.
Rectus femoris.
Vastus lateralis.
N. common peroneal, winding round head of fibula.
N. superficial peroneal, for peroneal muscles, provides the first seven collateral dorsal nerves of the foot.
Termination of the superficial peroneal, provides the last three collateral dorsal nerves for the toes.
N. femoral (motor point).
Pectineus.
N. obturator for the adductor muscles and gracilis.
Adductor brevis.
Adductor magnus.
Sartorius (in section).
Vastus medialis.
N. saphenous, sensory.
Tibial, for the tibialis anterior and the extensors of the toes.
Termination of the n. tibial, for the extensor digitorum brevis and the sensibility of the dorsum of the foot.

NERVES OF THE LOWER LIMB, ANTERIOR ASPECT.

pudendal nerve, and accessory branches which are distributed to the viscera and the pelvic muscles.

Superior Gluteal Nerve.—It emerges from the superior border of the notch, and reascends the lateral iliac fossa between the glutæus minor and the glutæus medius, which it supplies.

Cutaneus Femoris Posterior Nerve.—It comes out of the inferior portion of the notch, and descends to the medial portion of the thigh; it supplies the glutæus maximus and the skin of the perineum and of the inferior gluteal regions, posterior region of the thigh, and postero-superior region of the leg.

Pudendal Nerve.—Leaving the pelvis by the sciatic notch, it enters again by the lesser notch, is divided in the region of the ischium, and distributes its branches to the skin of the perineum and to the skin and muscles of the external genital organs.

Sciatic Nerve.—It descends from the sciatic notch to the popliteal space, to the middle of the posterior aspect of the thigh, under the glutæus maximus, then under the *biceps* which crosses it; it supplies this last muscle, as well as the *semimembranosus*, *semitendinosus*, and the *adductor magnus*. A little above the popliteal space it is divided into the common peroneal and the tibial.

The **Common Peroneal** proceeds downwards and outwards with the tendon of the biceps, winds round the head of the fibula, and supplies in this region the cutaneous suræ lateralis branch for the skin of the lateral portion of the leg, then divides into two branches:

The **Superficial Peroneal Nerve**, which descends between the *peronæus longus* and *peronæus brevis*, supplies these muscles, and terminates at the foot, giving off the first seven collateral dorsal nerves.

The **Deep Peroneal Nerve**, which descends with the anterior tibial artery between the *tibialis anterior*, the *extensor digitorum longus*, and the *extensor hallucis*, supplies these muscles, and terminates at the foot, where it supplies the *extensor digitorum brevis*.

The **Tibial** continues the vertical posterior direction of the

sciatic, traverses the popliteal space at the inferior portion, from which it gives off branches for the muscles *gastrocnemius*, *soleus*, and the *plantaris*, then divides into:

The **Cutaneous Suræ Medialis Branch,** superficial, sensory, which passes between the two heads of the gastrocnemius and supplies branches for the skin of the lateral portions of the leg and foot.

The **Tibial Nerve**, mixed, deeply situated under the soleus as far as the tendo Achillis, on the medial border of which it is placed, passes behind the medial malleolus, winds round the medial border of the calcaneus, and terminates at the sole of the foot, giving off the plantar nerves.

It supplies in the leg: the *soleus*, the *tibialis posterior*, and the flexors of the toes; in the foot: all the *plantar muscles*, the *lumbricales*, and *interossei*, and the skin of the sole of the foot.

Points of stimulation : the *sciatic* is accessible in the fold of the buttock and at the apex of the popliteal space.

N.C.Con.=10; P.C.Con.=17.

The *common peroneal* is accessible below the head of the fibula.

N.C.Con.=5; P.C.Con.=8.

The *tibial* is accessible at the inferior portion of the popliteal space and behind the medial malleolus.

N.C.Con.=4·5; P.C.Con.=7.

Zones of Cutaneous Sensibility of the Lower Limb.

(*Plate XXXII.*)

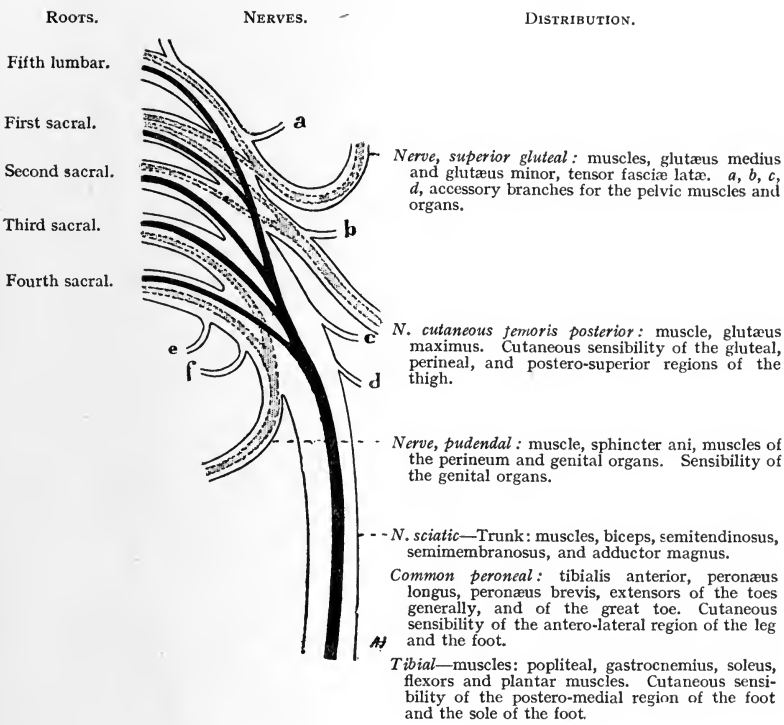
Thigh.—*Anterior aspect :* proximal fourth (Scarpa's triangle), genito-femoral nerve (lumbar plexus); distal three-fourths, region of the quadriceps; femoral nerve (lumbar plexus).

Posterior aspect : upper half of the buttock, ilio-inguinal nerve (lumbar plexus); the rest, cutaneous femoris posterior.

Lateral aspect : cutaneous branch of femoral (lumbar plexus).

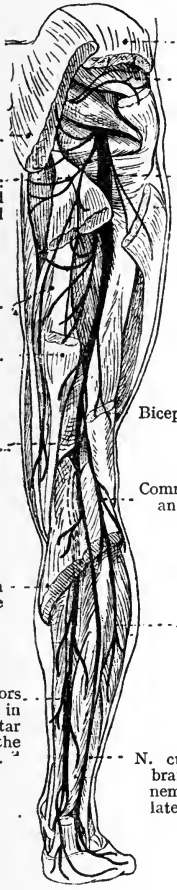
Medial aspect : obturator nerve (lumbar plexus).

PLATE XXX.


Roots.
Nerves.
Distribution.
Fifth lumbar.
First sacral.
Second sacral.
Third sacral.
Fourth sacral.
a
b
c
d
e
f
Nerve, superior gluteal: muscles, glutæus medius and glutæus minor, tensor fasciæ latæ. *a, b, c, d,* accessory branches for the pelvic muscles and organs.
N. cutaneous femoris posterior: muscle, glutæus maximus. Cutaneous sensibility of the gluteal, perineal, and postero-superior regions of the thigh.
Nerve, pudendal: muscle, sphincter ani, muscles of the perineum and genital organs. Sensibility of the genital organs.
N. sciatic—Trunk: muscles, biceps, semitendinosus, semimembranosus, and adductor magnus.
Common peroneal: tibialis anterior, peronæus longus, peronæus brevis, extensors of the toes generally, and of the great toe. Cutaneous sensibility of the antero-lateral region of the leg and the foot.
Tibial—muscles: popliteal, gastrocnemius, soleus, flexors and plantar muscles. Cutaneous sensibility of the postero-medial region of the foot and the sole of the foot.

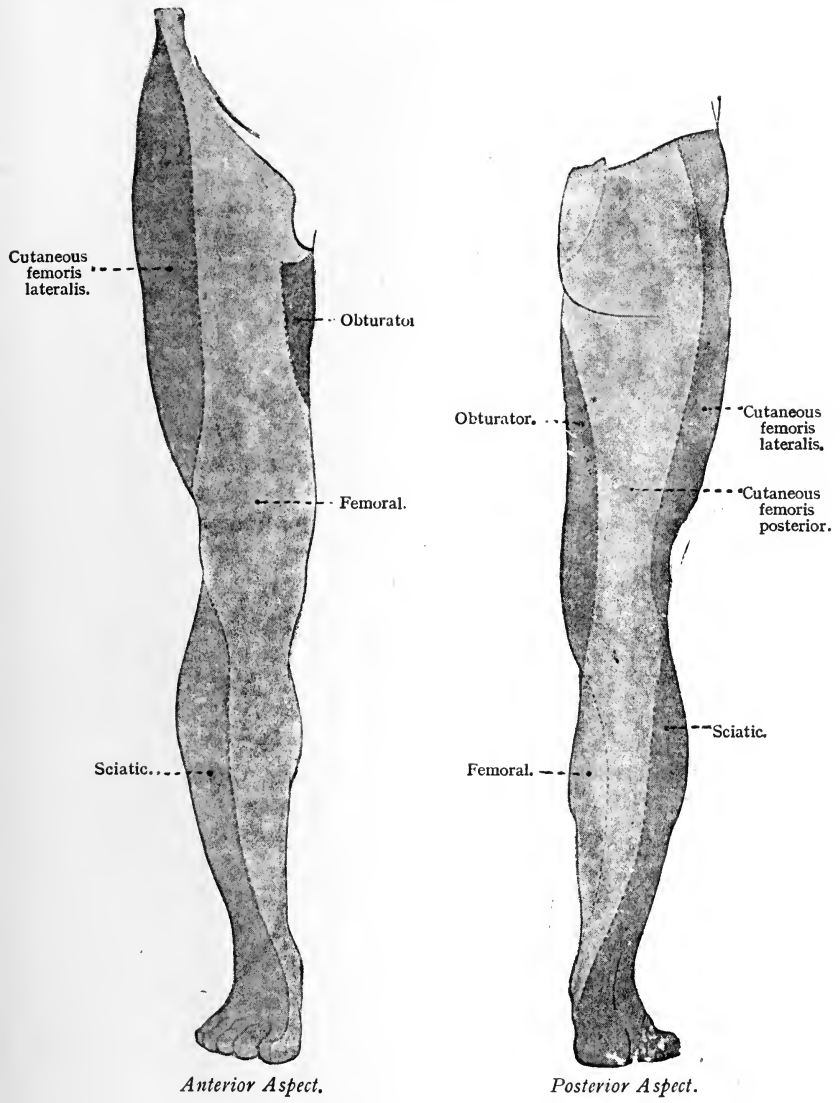
Sacral Plexus.

PLATE XXXI.


Glutæus medius.
N. superior gluteal.
Glutæus maximus.
N. cutaneous femoris posterior: for the glutæus maximus and the skin of the postero-medial region of the thigh.
N. sciatic: its branches for the posterior muscles of the leg.
Semimembranosus.
Semitendinosus (in section).
Biceps (in section).
Tibial.
Common peroneal: passing to the anterior aspect.
Gastrocnemius and soleus (in section), supplied by the branches of the tibial.
Accessory of the cutaneous suræ lateralis; sensibility of posterior aspect of the leg.
N. tibial: deep branch for the flexors and the tibialis posterior, ends in the medial and lateral plantar nerves for the muscles and the sensibility of the sole of the foot.
N. cutaneous suræ lateralis: superficia branch of the tibial for the gastrocnemius and soleus muscles and postero-lateral sensibility of the leg.

NERVES OF THE LOWER LIMB, POSTERIOR ASPECT.

PLATE XXXII.



ZONES OF CUTANEOUS SENSIBILITY OF THE LOWER LIMB.

Leg.—*Antero-lateral aspect :* superficial peroneal nerve (branch of the common peroneal).

Antero-medial aspect : saphenous nerve (branch of the femoral).

Posterior aspect : cutaneus femoris posterior.

Foot.—*Dorsal aspect :* superficial peroneal (branch of the common peroneal).

Lateral border : sural nerve.

Medial border : Saphenous nerve (femoral).

Sole.—Heel, posterior branch of the tibial nerve, the distal two-thirds plantar nerves (branches of the tibial).

V.—NORMAL EXCITABILITY OF NERVES AND MUSCLES.*

Motor Points.—They are not, properly speaking, points, but narrow zones of maximum excitability, corresponding, for the superficial muscles, with the points of penetration of the nerves, and for the deep nerves and muscles, with the points where they are most accessible to the electric swab. It is known that displacement of the motor point is observed in certain cases of degeneration.

The difference of excitability between the motor point and the other accessible portions of a superficial muscle is considerable, and varies from 1 to 7 or 8 milliampères. Thus the contraction of the biceps at the cathode obtained with 1 milliampère at the motor point is only obtained with 6 or 8 milliampères at 10 centimetres above, and with 4 or 5 milliampères at 10 centimetres below. It is, therefore, very important to place the electrode accurately on the region of the motor points. The topography of these points being subject to some variations, it is necessary to look for them in the neighbourhood of the zone indicated. *A current of sufficient intensity excites all the muscles of the same region.* In cases of very marked hypo-excitability of a nerve, the muscles of the region depending on nerves intact or less affected contract by the stimulation of contact before the muscles under examination; the measure of the excitability of the latter is thus rendered very difficult. Thus, in radial paralysis, the stimulation of the extensors with a sufficient current (10 to 12

* These notes are only an epitome of some personal observations on the stimulation of nerves and muscles, and on the establishment or employment of our coefficients of excitability.

It would be advisable to consult special treatises (Castex, Zimmern, Guilleminot, Larat, Nogier, Albert Weil) for the study of the various methods of electro-diagnosis and of the forms of apparatus, a description of which is beyond the compass of this book.

milliampères) provokes the contraction of the flexors before that of the extensors, which it becomes very difficult to perceive.

In some cases, the isolated stimulation of a muscle provokes the simultaneous contraction of another muscle, relatively distant, but affected by the same nerve; thus the stimulation at the thenar eminence of the adductor pollicis (ulnar nerve) sometimes provokes the contraction of the hypothenar muscle (ulnar nerve). It is a somewhat rare occurrence, but one of which it is good to be forewarned. The intensity of current necessary to obtain the stimulation of the nerves and the contraction of the muscles *shows a considerable variation in normal individuals*, by reason of the excitability of the nerves and muscles themselves or of the resistance of the tissues, more especially of the skin and of the cellular adipose tissue; it varies also under extrinsic conditions—*e.g.*, technique in examination, nature and dimensions of the electrodes, pressure exercised by the operator.

For these reasons, *examinations* made on different subjects, or on the same subject by different operators, do not always yield identical results. When the injuries are unilateral, it is always interesting to compare the injured side with the sound side; one can only draw conclusions from pathological modifications when the quantitative differences are sufficiently indicated. If the injuries are bilateral, one ought only to affirm hyper- or hypo-excitability outside the maximum and minimum limits shown on our tables of coefficients.

In every case it is important to use the **same technique**.

To establish our coefficients, we have proceeded in the following manner, which we consider particularly simple and up to date: the examinations are made with the help of an assistant, who handles the apparatus according to the instructions of the doctor; the latter confines himself to examining the organs; with one hand he applies the active electrode to the desired points with an average pressure; with the other hand he palpates the muscles or their tendons in such a way as to ascertain the area of contraction, which, except for the face and fingers, is much more perceptible to

the touch than to the sight; he assures himself at the same time that the muscles examined are not contracted voluntarily, or habitually in a state of contraction before the stimulation.

Apparatus.—*For the faradic stimulation,* a movable coil of moderate size (12 centimetres long), operated by three Leclanché cells; induction with wire of medium gauge; a lever interrupter; a scale graduated in centimetres, 15 centimetres in length, indicates the relative position of the two coils; zero is placed at 3 centimetres from the point where the primary coil begins to pass within the secondary, and the maximum (15 centimetres) at the point where the two coils completely overlap. The figures of the faradic shown on our tables represent in centimetres the lengths of this scale. *For the galvanic stimulation,* current supplied by accumulators or by a transformer branched from an electrical installation; milliampèremetre; reducer of potential; reversing key; interruptions one per second.

Electrodes.—Broad lumbar electrode, 20 centimetres by 20 centimetres, indifferent (positive), firmly secured by a belt; active electrode (negative), swab of 3 centimetres in diameter, well moistened, applied flat most frequently, but sometimes edgeways (facial).

The first contraction caused by the electric stimulation of a muscle at the motor point usually requires a much greater intensity than the following ones. There is at the beginning a greater resistance, *an inertia to overcome.* The difference between the first contraction (on closing the circuit) and the following ones with the galvanic battery often amounts to several milliampères. The two values are thus measured: the swab being applied as usual, the current is passed with growing intensity and with regular interruptions until the first contraction is produced. The current is thereupon reduced until the muscle is completely relaxed, and is then reapplied to produce fresh contractions. It is these that we have taken for our coefficients. They are of less amplitude, but more constant. We know that muscular contractions are provoked, not by the mere intensity of the current, but by abrupt variations of a current of given intensity. There

is contraction at the opening and at the closing of the circuit, but at different intensities:

$$\text{I.C.Con.} < \text{I.O.Con.}$$

I=intensity; C=closing of circuit; O=opening of circuit; Con.=contraction.

The contractions are caused also under unequal intensities at the positive and negative poles:

$$\text{I.N.C.Con.} < \text{I.P.C.Con.}$$

Thus, the four distinct values which have to be found, from the point of view of the required intensities, are distributed normally in the following relations:

$$\text{I.N.C.} < \text{I.P.C.} < \text{I.P.O.} < \text{I.N.O.}^*$$

Examples: median nerve at the bend of the elbow: N.C.Con.=2·8; P.C.Con.=3·8; P.O.Con.=4; N.O.Con.=7·5. Biceps: N.C.Con.=1·2; P.C.Con.=2; P.O.Con.=2·1; N.O.Con.=4.

Modifications of these normal relations are observed in certain pathological cases, and the research for these modifications is rightly considered as very important in electrodiagnosis; one finds habitually, in fact, in cases of degeneration, either inversion of the formula P.C.Con. < N.C.Con. or equality, P.C.Con.=N.C.Con.; but it is necessary to know, and it is a result from our researches, that, even in a normal state, these relations vary greatly according to organs and individuals. Thus, the relation $\frac{\text{N.C.Con.}}{\text{P.C.Con.}}$, which in practice is in most cases the only one we need look for, varies from half to four-fifths. One observes sometimes even in healthy subjects the equality or inversion of the formula.

Here are, by way of examples, figures we have taken from healthy subjects:

* These relations are generally presented in an inverse form—

$$\text{N.C.Con.} > \text{P.C. Con.} > \text{P.O. Con.} > \text{N.O. Con.}$$

—with this signification, that for the *same intensity of current* the contraction is greater at N.C. than at P.C., at P.C. than at P.O., and so on. As the stated values express the various intensities of current required to obtain *the same contraction*, it appears to us to be more correct to write the formula in terms of current intensity.

Brachial plexus (Erb's point):

N.C.Con. : 3 mma.	1	2·5	4	4	2	2·5	2	5
P.C.Con. : 6 mma.	2	3	6	7	2	2	3	10

Biceps:

2	0·5	1·5	1	2	1	0·5	0·5	0·8
4	1	2·5	3	2·5	1·5	1·5	1	1

Flexor digitorum sublimis:

4	3	5	4	3·5	7	5	3	5	4
5	3·5	7	5	3·5	9	7	5	5	4·5

One sees from this how important it is to be reserved in formulating conclusions in electro-diagnosis, and that, to arrive at certainty, many concordant data are necessary, and that one must only take count of decided differences in a comparison of figures.

A confirmed habit of technique and appreciation is also indispensable. These reservations made, it is none the less an established fact that the measure of the excitability of the nerves and muscles to the different electric currents yields precise and extremely useful data for the clinic.

We give, by way of examples, after our tables of coefficients, some types of electro-diagnosis in very marked cases.

VI.—NORMAL COEFFICIENTS OF EXCITABILITY OF THE NERVES AND MUSCLES.

	Faradic, in Centimetres as per Scale.		*Galvanic, in Milliampères. N.C.Con.*		*Galvanic, in Milliampères. P.C.Con.*	
	From—	*Average.*	*From—*	*Average.*	*From—*	*Average.*
FACIAL NERVE (trunk)	1 to 5	3·5	2 to 6	4	3 to 8	5·5
Frontalis	0·5 to 4	2	1·2 to 4	1·5	1 to 5	3
Orbicularis oculi	1 to 7	4	2 to 6	4	3 to 8	5
Zygomaticus and Caput zygomaticum	1·5 to 7	4	2 to 7·5	5	4 to 9	6·5
Orbicularis oris	1·5 to 7	4	2·5 to 8	5·5	4 to 10	7
Platysma	1·5 to 7	4	2 to 7	5	4 to 9	6·5
Trigeminal: temporal masseter	3 to 5	4	2 to 6	3·5	2·5 to 8	4·5
CERVICAL PLEXUS:						
Trapezius	1·5 to 5	2·5	0·5 to 3·5	1·5	1 to 6	3
Sternomastoid	2 to 4	3·2	1·5 to 5	3	2·5 to 8	4
Rhomboid	2 to 5	3	2 to 7	3·5	4 to 12	6
Scaleni	2 to 4·5	3·5	1·5 to 4·5	3·5	2·5 to 8	4·5
BRACHIAL PLEXUS (Erb's point)	2·5 to 4·5	3·2	1 to 5	2·7	2 to 10	5
Pectoralis major	2·5 to 4·5	3	1·5 to 4	2·5	2·5 to 7	4
Serratus anterior	2·5 to 4·5	3	3 to 8	5·5	4 to 12	7
Infraspinatus	2·5 to 5	3·5	4 to 8	6	4 to 10	7
Deltoid (axillary)	1·5 to 3·5	2·9	0·5 to 5	2	1 to 7	3·5
Biceps (musculo-cutaneou)	0·5 to 3	1·5	0·5 to 2·5	1·2	1 to 4	2
Brachialis anterior (musculo-cutaneous)	2 to 3·5	2·9	1 to 3·5	1·5	2 to 5	2·5

NORMAL COEFFICIENTS OF EXCITABILITY OF THE NERVES AND MUSCLES—*Continued.*

	Faradic, in Centimetres as per Scale.		*Galvanic, in Milliampères. N.C.Con.*		*Galvanic, in Milliampères. P.C.Con.*	
	From—	*Average.*	*From—*	*Average.*	*From—*	*Average.*
RADIAL NERVE (at the elbow)	2·5 to 6	3·5	2 to 6	3·5	3·5 to 10	5
Triceps	2·5 to 4	3·4	2·5 to 7	3·8	3 to 11	6·8
Extensors	2·2 to 4	3·4	2 to 5	4·3	3 to 11	6
Extensor carpi radialis longus	2·5 to 4·5	3·5	2·5 to 6	4	3·5 to 8	5
Brachio-radialis	2·5 to 5·5	3·5	2 to 6	4·5	3·5 to 8	5·5
Extensor carpi ulnaris	2 to 6	4	2·5 to 6	3·5	3 to 7	4·5
ULNAR NERVE (at the elbow)	2·5 to 5	3·5	2 to 5	2·8	3 to 6·5	3·7
Flexor carpi ulnaris	2·8 to 5	3·7	2·5 to 5·5	3	3·5 to 7	4
Hypothenar	3 to 4·5	3·7	2 to 6	4	3 to 8	5·3
Interossei	3 to 5·5	3·7	2 to 6	4	3·5 to 7	5
MEDIAN NERVE (at the fold of the elbow)	2 to 5	3·3	1·5 to 6	3	2·5 to 9	5·5
Pronator teres	2 to 5	3·5	2 to 6	4	2·5 to 8	5·5
Flexor carpi radialis	2·5 to 5	3·5	2 to 5	3·5	2 to 7	5
Flexor digitorum sublimis	2·3 to 5	3·4	3 to 7	4·3	2·5 to 9	5·4
Thenar (flexor brevis)	2·5 to 4·5	3·5	1·5 to 5	3·8	2 to 7·5	5
THORACIC NERVES:						
Obliquus externus	3 to 5	4	2 to 5	3	3·5 to 8	4·5
Rectus abdominis	3·5 to 4·5	4	2·5 to 6	3·5	3·5 to 8	5
Latissimus dorsi	3·5 to 5·5	4·5	2·5 to 7	4	3 to 9	6
Sacrospinalis	3·5 to 5	4	2·5 to 7	4	3 to 9	6

NORMAL COEFFICIENTS OF EXCITABILITY OF THE NERVES AND MUSCLES—*Continued.*

	Faradic, in Centimetres as per Scale.		*Galvanic, in Milliampères. N.C.Con.*		*Galvanic, in Milliampères. P.C.Con.*	
	From—	*Average.*	*From—*	*Average.*	*From—*	*Average.*
LUMBAR PLEXUS:						
Femoral nerve	2·5 to 5·5	3	2·5 to 8	5·5	5 to 12	9·5
Quadriceps	2·5 to 5·5	3·5	3 to 11	7·5	6 to 16	12
Sartorius	2·5 to 5·5	3·5	4 to 10	5·5	5 to 12	9
Adductor longus	1·5 to 4·5	2·5	2·5 to 8	4	3 to 9	5·5
Gracilis	1·5 to 3·5	2	2 to 6	3·5	2 to 7	5
SACRAL PLEXUS:						
Glutæus maximus (cutaneous femoris posterior)	2·5 to 5·5	4·2	3 to 14	8	5 to 20	13·5
Glutæus medius	2·5 to 5·5	4·2	3 to 14	8	5 to 20	13·5
Sciatic nerve (in the fold of the buttock)	2 to 7	4·3	3·5 to 18	10	5 to 25	17
Biceps	2 to 5	3·7	8 to 17	11·5	9 to 25	16
Semi membranosus	2 to 5	4	8 to 18	12	9 to 22	16
TIBIAL NERVE	2 to 6	4·5	4 to 10	5·5	5 to 12	7
Gastrocnemius	1·5 to 4·5	3·7	5 to 10	7·5	8 to 14	10
Flexor digitorum longus	3 to 6	4·5	6 to 12	9	8 to 16	15·5
Medial plantar muscles	5 to 10	7	6 to 12	8	8 to 15	12
Interossei dorsales	3 to 6·5	4·5	4 to 12	6	5 to 13	8
COMMON PERONEAL NERVE	2 to 7	4	3·5 to 13	5	5 to 15	8
Tibialis anterior	2·5 to 6	4	4·5 to 15	8	8 to 18	10·5
Extensores digitorum	2·5 to 6	4	5 to 15	8	7 to 16	10
Peronæi	3 to 5·5	4·5	5 to 16	8	6 to 20	11
Extensor digitorum brevis	3 to 7	5	3 to 8	4·5	4 to 10	7

VII.—OBSERVATIONS OF ELECTRO-DIAGNOSIS.

I. G., aged twenty-six, partial paralysis of the left upper limb. Result of wound in arm, fracture by bullet.

	Faradic.		*Galvanic.*				*Various Observations.*
	Right.	*Left.*	*Right.*		*Left.*		
			N.C.	*P.C.*	*N.C.*	*P.C.*	
	cm.	cm.	mma.	mma.	mma.	mma.	
Brachial Plexus (Erb's point)	2·4	2·8	4	6	5	7	—
Deltoid	2·4	3	3	4	2	3	—
Biceps	1·4	2·3	1·5	3	6	8	—
Triceps	2·3	3·5	2·5	3	6	11	—
Median Nerve	2·5	Nothing with 10	3·5	4·5	**7**	**7**	Slow contraction.
Flexor digitorum sublim's	2·8	,, ,, 10	4	5	**8**	**7**	
Thenar (flexor brevis)	2·4	,, ,, 10	4	6	**6·5**	**4**	
Ulnar Nerve (at the elbow)	2	5	3·5	4·5	**6·5**	**7**	
Flexor carpi ulnaris	2·2	4·6	3·5	5	**7**	**6**	
Hypothenar (abductor)	2·4	Nothing with 10	4	5	**6·5**	**4·5**	
Interossei	2·8	,, ,, 10	4	5	6·5	5	—
Radial Nerve (at the elbow)	2·3	2·8	3·5	4·5	4	5·5	—
Extensors	2·5	2·7	4	5	4	6	—
Brachioradialis	2	3	4	5	5	6	—

Conclusions.—Abolition of faradic excitability; strong hypo-excitability to the galvanic current, with inversion and slow contraction in the area of the median and ulnar nerves, the latter less marked slight lesions of the musculo-cutaneous and the radial.

OBSERVATIONS OF ELECTRO-DIAGNOSIS—*Continued.*

F. L., aged twenty-three, bullet wound in right shoulder, partial paralysis.

	Faradic.		*Galvanic.*				*Various Observations.*
	Right.	*Left.*	*Right.*		*Left.*		
			N.C.	*P.C.*	*N.C.*	*P.C.*	
	cm.	cm.	mma.	mma.	mma.	mma.	
Brachial Plexus (Erb's point)	3·8	3	6	10	4	7	—
Deltoid	4·5	2·5	10	10	4	6	—
Biceps	4	1·7	3	5	0·5	1·5	—
Triceps	6·5	3·6	13	12	6	11	—
Median Nerve (at the elbow)	4	3·5	5	7	3·5	5·5	—
Flexor	4·5	4	6	6·5	5	7	—
Thenar (flexor brevis)	4·5	3·3	5	6	3·5	4	—
Ulnar Nerve (at the elbow)	4·5	3·5	5	6·5	4	5·5	—
Flexor carpi ulnaris	4·5	3·5	5	6	3·5	4·5	—
Hypothenar (abductor)	5	3·9	5	5·5	3·5	4	—
Interossei	4·5	3·5	5·5	6	4	5	—
Radial Nerve (at the elbow)	Nothing with 12	3·5	10	12	4	5	—
Extensors	,, ,, 12	4	10	11	4·5	5·5	—
Brachio-radialis	,, ,, 12	3·5	10	10	4	5	—

Conclusions.—Marked hypo-excitability of all the plexus; grave lesions of the axillary, the musculo-cutaneous, and especially the radial; slight affection of the median and the ulnar.

OBSERVATIONS OF ELECTRO-DIAGNOSIS—*Continued.*

Ch. M., aged thirty-five, old bullet wound in the left thigh.

	Faradic.		*Galvanic.*				*Various Observations.*
	Right.	*Left.*	*Right.*		*Left.*		
			N.C.	*P.C.*	*N.C.*	*P.C.*	
	cm.	cm.	mma.	mma.	mma.	mma.	
FEMORAL NERVE	4·5	7	7	11	16	22	Œdema of all the lower limb.
Rectus femoris	5	8·5	7	12	20	24	—
Sartorius	5	8	6	10	14	20	—
Glutæus maximus	4·5	8	8	12	17	25	—
SCIATIC NERVE	5·5	Nothing with 12	12	17	Nothing with 30		Profoundly adherent cicatrice in this region.
Biceps	4·5	,, ,, 12	11	15	19	25	
Tibial nerve	4·5	,, ,, 12	10	14	Nothing with 30		—
Gastrocnemius	4·5	,, ,, 12	8	9	25	30	—
Common peroneal nerve	5	,, ,, 12	11	14	Nothing with 30		—
Tibialis anterior	6	,, ,, 12	8	11	,,	,, 30	—
Peronæi	6	,, ,, 12	8	11	,,	,, 30	—

CONCLUSIONS.—Hypo-excitability very marked in the whole of the lower limb; degeneration of the sciatic, slight affection of the femoral and the posterior cutaneous nerve of the thigh.

OBSERVATIONS OF ELECTRO-DIAGNOSIS—*Contniued.*

F. B. R., aged fifty-two, left leg sciatic, rheumatism.

	Faradic.		*Galvanic.*				*Various Observations.*
	Right.	*Left.*	*Right.*		*Left.*		
			N.C.	*P.C.*	*N.C.*	*P.C.*	
	cm.	cm.	mma.	mma.	mma.	mma.	
Femoral nerve	3·3	3·6	3	4	3	4·5	—
Rectus femoris	3·8	3·8	7·5	10	9	12	—
Sartorius	3·5	3·8	5	9	8	12	—
Glutæus maximus	4·5	5·5	4	7	8	10	—
Sciatic Nerve	4·3	3·5	7	9	4	7	—
Biceps	4	6	9	13	16	17	—
Tibial nerve	4·5	3·5	7·5	10	5	7	—
Gastrocnemius	3	4·5	8	10	15	15	—
Common peroneal nerve	4·5	3·5	7	10	5	7	—
Tibialis anterior	3	5·5	8	11	20	22	—
Peronæus	3·5	4·5	9	13	14	15	—

Conclusions.—Sciatic neuritis, hyper-excitability of the nerve, hypo-excitability of the muscles.

OBSERVATIONS OF ELECTRO-DIAGNOSIS—*Continued.*

M. V., aged twenty-four, bilateral general neuritis, paludism.

	Faradic.		*Galvanic.*				*Various Observations.*
	Right.	*Left.*	*Right.*		*Left.*		
			N.C.	*P.C.*	*N.C.*	*P.C.*	
	cm.	cm.	mma.	mma.	mma.	mma.	
BRACHIAL PLEXUS (Erb's point)	4·5	3·5	5	9	1	2	Atrophy and asthenia of the limbs, especially the lower.
Deltoid	**4**	**5**	1	2	1	1·5	
Biceps	**4**	**4·5**	0·5	1	1	2	
Triceps	**6**	**5·5**	3	5·5	3·5	5·5	
Extensors	**6·5**	**5·5**	3	5	3	5	
MEDIAN NERVE	4·5	4·5	3	5	3·5	6	—
Flexors	5·3	5	2·5	4	2	4	—
Thenar (flexor brevis)	**5**	**5**	3·5	4·5	3·5	5	—
Flexor carpi ulnaris	5·5	5	3·5	5	3	5	—
Hypothenar	**5**	**5·5**	2	3	2	2·5	—
FEMORAL NERVE	**7**	**6**	6	10	8	16	—
Rectus femoris	**6·5**	**8·5**	9	14	9	12	—
Adductors	**5**	**7·5**	**8**	**15**	**10**	**13**	—
SCIATIC NERVE	**9**	**12**	**25**	**25**	**20**	**25**	—
Biceps	**7·5**	**9·5**	10	14	**18**	**20**	—
Common peroneal nerve	5	**7**	7	15	5	10	—
Tibialis anterior	**7·5**	Nothing with 12	7	10	**9**	**1**	—
Extensors	**7·5**	,, ,, 12	**10**	**10**	**10**	—	—
Peronæi	5	5·5	8	11	9	1	—
Tibial nerve	**7**	7	9	12	8	10	—
Gastrocnemius	**11**	**11**	**12**	**18**	**12**	**13**	—

CONCLUSIONS.—Hypo-excitability with the faradic for the greater number of the muscles, especially in the lower limbs, more marked on the left (common peroneal).

Slight galvanic hypo-excitability in the area of the two sciatics, particularly in the left common peroneal (polyneuritis).

Note.—The numerals in black are outside the limits of normal excitability.

VIII.—ARTICULATIONS.

General Characters.

As a general rule the different articulations, and particularly those of the limbs, are organised to allow of supple *movements* of more or less amplitude, and at the same time to maintain with sufficient solidity the general statics of the body and of its different segments.

The *articular surfaces* are most often curved and adapted one to another; a concave surface answers to a convex surface, and *vice versa ;* the curves fitting into one another are often very different in different cases and sometimes even opposed to each other—for example, in the form of a saddle or pulley.

These surfaces are covered with an envelope, more or less thick, of adherent *cartilage,* named hyaline, which gives them a more regular curve and a more uniform polish.

Between them are sometimes interposed pads or *fibro-cartilaginous* menisci, which enlarge the cavities and serve as an elastic cushion.

The articular extremities are maintained in contact by a *fibrous capsule,* a sort of ligamentous muff more or less thick and homogeneous, which is inserted at the circumference of articular surfaces; separate *ligaments* generally strengthen this capsule at its weak points, and especially on the sides where the movements are the least extensive.

The neighbouring *muscles,* and particularly the tendons inserted at the circumference, which are often in actual contact with the capsule, are also powerful agents of reinforcement, and constitute veritable active ligaments; atrophy and paralysis of these muscles bring about generally a more or less marked flaccidity of the corresponding articulation.

A *synovial* or serous membrane covers the internal aspect of the capsule, and secretes a ropy liquid or synovia, which moistens the articular surfaces and facilitates their movements.

Movements.—The different articulations in different directions have a *normal amplitude*, which varies slightly among individuals, and which is sensibly increased by exercise or by certain substitutes. We will indicate for each articulation the average amplitude of the principal movements which may be considered as relatively constant.

(See recapitulatory table, p. 98).

Articulatio Mandibularis, or Temporo-mandibular Joint.

(*Plate XXXIII.*)

Articular Surfaces.—*Glenoid fossa of the temporal bone*, slightly hollowed out, with its long axis nearly transverse under the zygomatic arch in front of the external acoustic meatus.

Condyle of the mandible, rounded transversely and in the antero-posterior direction, attached to the ascending ramus by the neck of the condyle.

Means of Union.—A *fibro-cartilaginous meniscus*, biconcave, separates and adapts one surface to the other, the two surfaces forming, with two independent synovial membranes, two distinct articulations: menisco-temporal and menisco-mandibular.

A *fibrous capsule*, rather loose but tough, reinforced by the anterior and posterior portions of the temporo-mandibular *ligament*, by the spheno-mandibular ligament, which goes from the spine of the sphenoid bone to the aspect of the ramus, and by the pterygo-mandibular and stylo-mandibular ligaments.

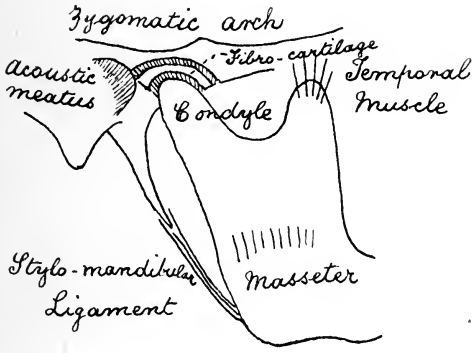
The external and internal *pterygoid muscles*, which are inserted, the first in front on the capsule of the articulation, the second on the medial surface of the mandible, the *temporal* inserted in the coronoid process, and the *masseter* on the lateral surface of the ramus, constitute active ligaments for the statics as well as for the movements of the jaw.

Movements.—All are due to the displacement of the mandible on the temporal, which remains stationary.

Lowering (opening of the mouth) by rotation of the condyle from behind forwards, under the action of the platysma, digastric and mylo-hyoid muscles.

Amplitude, 25° to 30°.

PLATE XXXIII.



ARTICULATIO MANDIBULARIS (MANDIBULAR JOINT).

Elevation, or return to the normal position (closing of the mouth), by the temporal muscle and the masseter.

Propulsion : 10° to 12° by the external pterygoid, and return backwards by the posterior fibres of the temporal muscle.

Side movements to right and left by the internal right or left pterygoid muscles; amplitude, 15° on each side, 30° in all.

Articulations of the Vertebræ.

(*Plate XXXIV.*)

As a general rule, the vertebræ articulate with each other by means of the broad, horizontal, slightly hollowed surfaces of the *vertebral bodies*, and the narrow almost flat surfaces, more or less oblique, of the *articular processes*.

The bodies are separated by a fibro-cartilage, in the centre of which is a soft, gelatinous, and elastic substance which hardens with age. The articular processes are separated by a synovial membrane.

The circumference of these surfaces gives insertion to fibrous capsules. Those of the vertebral bodies are powerfully reinforced by thick broad anterior and posterior common ligaments.

The *laminæ*, the *transverse processes*, the *spinous processes*, which, from one vertebra to another, are separated by intervals of 8 to 15 millimetres, are attached by:

Yellow ligaments, very elastic, which unite the laminæ and enclose the spinal canal behind and on the sides; by inter-transverse right and left ligaments, which bind the transverse processes by:

Inter- and supra-spinous ligaments, which unite the spinous processes on the middle posterior line. The whole forms a fairly supple and very tough system, answering to the conditions of the vertical position, and allowing of anterior or lateral flexion, especially extensive in the cervical region.

Cervical Vertebræ.—They are distinguished by various peculiarities: bodies thinner and more hollowed out, shorter transverse processes, a more open spinal canal, a more supple articular disposition, allowing of more complex movements.

The first two, the *atlas* and the *epistropheus*, in direct

communication with the cranium, have a still more distinct form and a special manner of articulation. Besides the projections common to all vertebræ, the epistropheus presents a powerful vertical articular process surmounting its vertebral body: the dens.

The body of the atlas, on the contrary, almost entirely hollowed out to make room for the dens of the epistropheus, is reduced to a bony ring, thin in front and behind (anterior and posterior arches), but strengthened on the sides (lateral masses), which present broad articular surfaces.

Articulation of the Atlas and the Epistropheus.—It comprises:

First, the *two lateral articulations*, right and left, practically horizontal, of the articular processes (superior of the epistropheus, inferior of the atlas), each provided with a capsule and a synovial membrane, and analogous to the other intervertebral articulations of the processes.

Secondly, the middle vertical articulation of the dens with the anterior axis of the atlas.

In front a small dental facet corresponds with the middle portion of the anterior arch of the atlas; a capsule and a synovial membrane bound this small articulation.

Behind, a large ligament, called the transverse semicylindrical ligament, attached on each side to the lateral masses of the atlas, and by vertical medial extensions to the occiput and to the body of the epistropheus, encloses the posterior two-thirds of the dens.

There is also a synovial membrane for this posterior articulation.

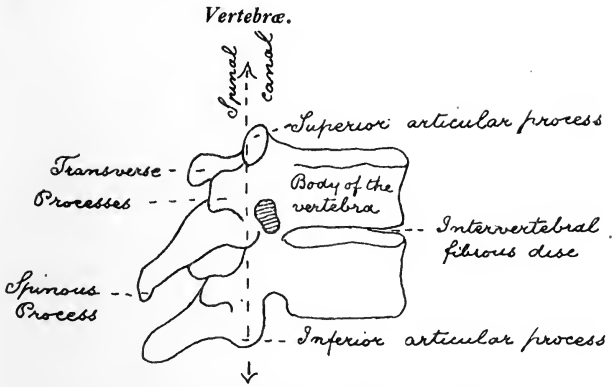
Articulation of the Occipital Bone and the Atlas.—The two condyles of the occipital bone, situated on the lower surface of the bone, near the foramen magnum, articulate on a plane practically horizontal with the corresponding glenoid surfaces on the superior surface of the lateral masses of the atlas.

Each of these two articulations has a capsule and a synovial membrane.

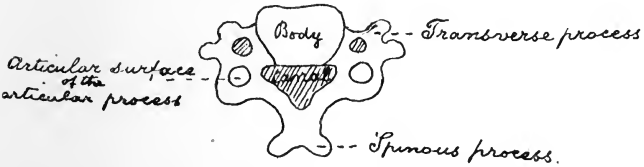
Many complementary ligaments bind the occipital bone to the atlas and the epistropheus:

The *atlanto-occipital ligaments*, anterior and posterior, which

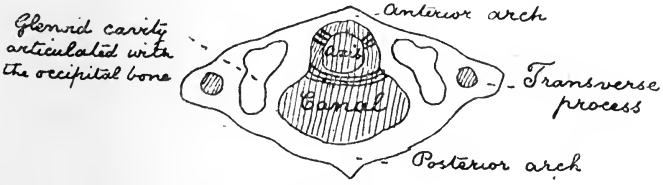
PLATE XXXIV.



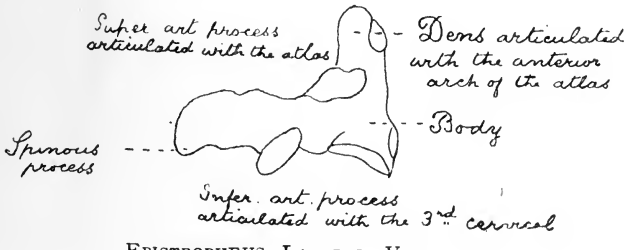
TWO DORSAL VERTEBRÆ, LATERAL VIEW.



CERVICAL VERTEBRA, SUPERIOR VIEW.



ATLAS, SUPERIOR VIEW.


Super. art. process articulated with the atlas
Dens articulated with the anterior arch of the atlas
Body
Spinous process
Infer. art. process articulated with the 3rd cervical

EPISTROPHEUS, LATERAL VIEW.

go from the borders of the occipital foramen to the arches of the atlas.

The *occipito-epistropheal ligaments*, which go from the anterior border of the occipital foramen to the body of the epistropheus.

The *occipito-dental middle and two lateral ligaments*, which go from the basilar process to the apex of the dens.

The numerous muscles of the neck and the nape, deep and superficial, complete these means of union of the cervical vertebræ and the occipital bone, and preside over their movements.

Movements of the Head and Neck.

Anterior Flexion of the Head.—About 35° from the normal attitude (looking horizontally in a standing position), due to the bilateral action of the scaleni, sternomastoid, anterior rectus muscles, platysma, and supra- and infra-hyoid muscles.

Posterior Extension.—About 40°, due to the bilateral action of the muscles of the nape: trapezius, posterior rectus muscles, splenius, and semispinalis capitis.

Extension and flexion occur for about 40° between the atlas and the occipital bone, and for the remainder among the cervical vertebræ.

Inclination or Lateral Flexion.—30° on each side, due to the unilateral action of the sternomastoid, scaleni, and lateral rectus muscles.

Movement distributed among the various cervical vertebræ.

Rotation of the Head.—About 70° on each side, due to the unilateral action of the extensors of the head, and particularly of the obliquus superior and the obliquus inferior.

Two-thirds of the movement is referred to the joint between the atlas and the dens, and one-third to other vertebral joints.

Articulations of the Shoulder Girdle.

(*Plates XXXV., XXXVI.*)

The shoulder girdle, which encircles the apex of the thorax, is formed by the clavicle and the scapula.* These two bones, joined at an angle of about 75°, have two points of contact and articulation: acromio-clavicular and coraco-clavicular.

* Miramond de Laroquette, "Etude Anatomique de la Ceinture Scapulaire" (*Revue d'Orthopédie*, 1907).

The **Acromio-clavicular Articulation,** arthrodial joint with flat surfaces, joins the flattened acromial end of the clavicle to the medial aspect of the acromion.

Separated by a synovial membrane and a fibro-cartilaginous meniscus, these very narrow surfaces are maintained by a fibrous capsule which is strengthened by a superior and an inferior ligament.

The **Coraco-clavicular Ligaments**, called trapezoid and conoid, are very tough; they bind the base of the coracoid process to the inferior surface of the clavicle.

Provided very often in their deep surface with a small synovial membrane, these ligaments and the surfaces they bind constitute a special articulation with an intermittent contact, which serves as a pivot for the movements of rotation for the scapula on the clavicle.

The shoulder girdle is attached to the thorax by the sterno-clavicular articulation, the costo-clavicular ligament, and the scapulo-thoracic junction.

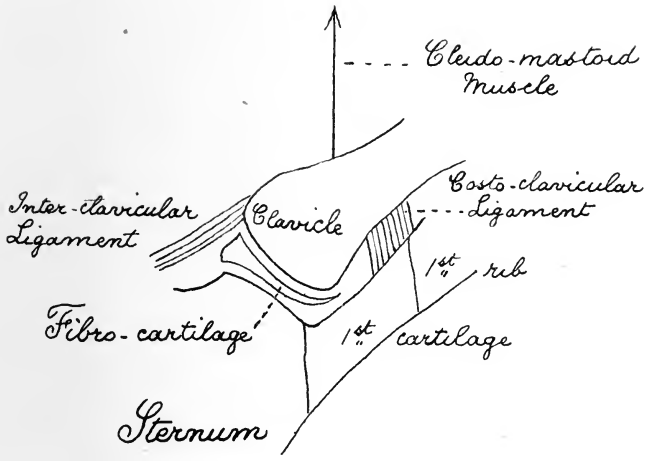
The **Sterno-clavicular Articulation** is an incomplete enarthrosis; the medial extremity of the clavicle rolls in a sort of glenoid cavity formed by the sternal notch of the first costal cartilage; a fibro-cartilage and a double synovial membrane facilitate the movements between these two surfaces.

They are held in place by a fibrous muff, strengthened by superior sterno-clavicular ligaments, anterior and posterior ligaments, and by the interclavicular ligament, which unites the two right and left articulations.

The **Costo-clavicular Ligament**, short and very tough, situated about 1 centimetre lateral to the joint between the clavicle and the first rib, usually possesses a small serous bursa, and it constitutes, like the coraco-clavicular ligaments, an articulation with intermittent contact. The clavicle has a point of support at this level on the first rib in certain movements, and in the vertical position, in the low attitude of the upper limb; it is apart from the rib during the elevation of the arm.

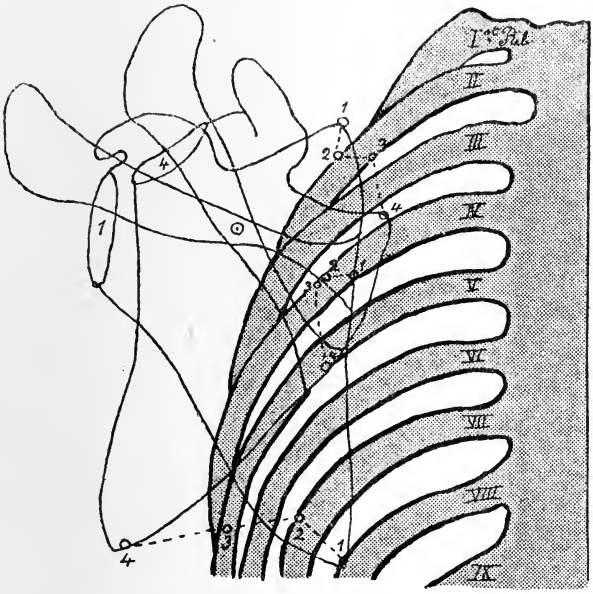
The **Sterno-costo-clavicular Articulation** serves as a pivot and regulator in all the movements of the shoulder girdle.

PLATE XXXV.



THE STERNO-COSTO-CLAVICULAR ARTICULATION.

PLATE XXXVI.



ROTATION OF SCAPULA (AFTER A RADIOGRAPH) DURING ABDUCTION AND LATERAL ELEVATION OF THE ARM.

1, Normal attitude, arm alongside the body; 2, arm at 45°, rotation of scapula from 1 to 2= 15°; 3, arm stretched to 90°, rotation of scapula from 2 to 3= 10°; 4, arm raised to the maximum 150°, rotation of scapula from 3 to 4= 25°; total extent of the movement of rotation of scapula= 50° (the movement, regulated chiefly by the muscles trapezius and serratus anterior, has for its centre an area in the middle of the spine).

Scapulo-thoracic Junction.

(*Plate XXXVI.*)

A special articulation which comprises, though partially differentiated, the ordinary elements of articulation.

Surfaces.—*Posterior thoracic wall* between the second and eighth ribs, with the corresponding intercostal muscles; *anterior aspect of the scapula*, padded with the subscapular muscle; between them the muscle *serratus anterior*, placed obliquely from the medial border of the scapula in all its height to the axillary region of the ribs; the *interscapular* space is thus divided into two prismatic cells furnished with a *loose cellular tissue* which takes the place of a synovial membrane and facilitates gliding movements.

Means of Union.—No fibrous ligaments, but muscles (veritable elastic ligaments) suitable for the large displacements of the scapula—*i.e.*, serratus anterior, rhomboidei, trapezius, and, indirectly, all the muscles of the shoulder.

Movements.—They are very extensive and varied: displacements in mass, in height (raising the shoulders), or in breadth, and rotation of the scapula on an axis adjacent to the supero-medial angle (bell-like movement); this action, more especially when combined with the movements of the shoulder for the elevation and abduction of the arm, in which it intervenes to the extent of a third (50°), is due to the concordant actions of the trapezius and the serratus anterior.

ARTICULATIONS OF THE LIMBS

Articulation of the Shoulder, or Scapulo-humeral.

(*Plate XXXVII.*)

Surfaces.—*Head of the humerus*, a hemisphere covered with cartilage; *glenoid cavity* of the scapula, oval, slightly hollowed, enlarged by a fibro-cartilaginous pad, protected above by the acromion.

Ligaments.—A strong fibrous capsule attached to the anatomical neck, to the pad and to the circumference of the glenoid cavity, strengthened especially in front and above

by the gleno-humeral ligaments, and by the tendons of the muscles, subscapularis, supra- and infra-spinatus, teres minor, triceps, and biceps.

Synovial Membrane.—Covering the internal aspect of the capsule, with an important inferior blind alley below the glenoid cavity. The articulation, concealed to the extent of three-quarters by the *deltoid*, which is a powerful active ligament for it, is in relation at its internal portion with the *vasculo-nervous* mass of the upper limb.

Movements.—Abduction and elevation of the arm, anterior, lateral, posterior, and in the intermediate planes; complex movements which take place simultaneously in the scapulo-humeral articulation and the scapulo-thoracic junction; the humeral head glides and turns in the scapular cavity at the same time as the scapula is displaced and pivots on the thorax; the measurement by compass (directly on the skin or radiograph) of the scapulo-humeral angles in the different stages of the movements of the shoulder determines the part which in these movements pertains to these two articulations; the movement of lateral elevation of the arm has an average total amplitude of 150°, of which 95° to 100° occur in the articulation of the shoulder, and 50° in the scapulo-thoracic junction. The movements of the two articulations are simultaneous at different stages, and nearly in the following proportions:

Starting at the low vertical position—the arm alongside the body:

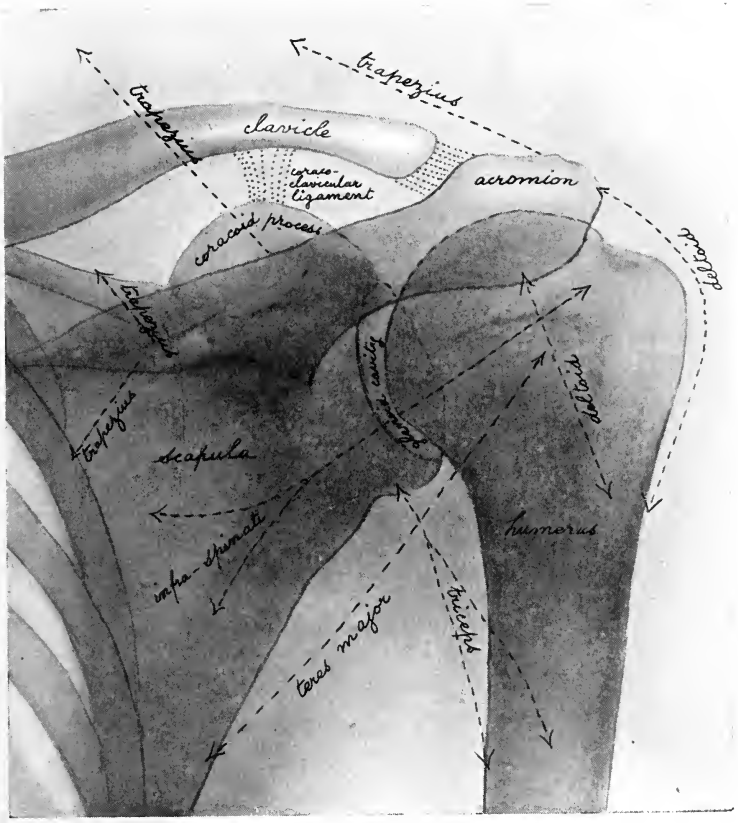
	Movement of Humerus on Scapula.	Movement of Scapula on Thorax.
First stage: arm at 45°	30°	15°
Second stage: arm horizontal at 90° ..	35°	10°
Third stage: arm raised to the maximum, 150°	35°	25°
	100°	50°

The combined elevation and depression of the arm in antero-posterior planes constitutes the movement of rotation or of circumduction.

Average amplitude, 150°.

There is also a slight movement of rotation or torsion of the humerus on its longitudinal axis, about 80°.

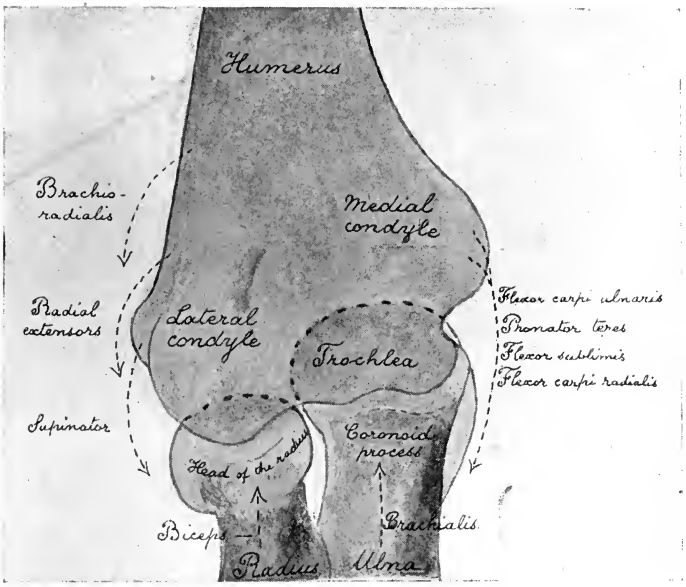
PLATE XXXVII.



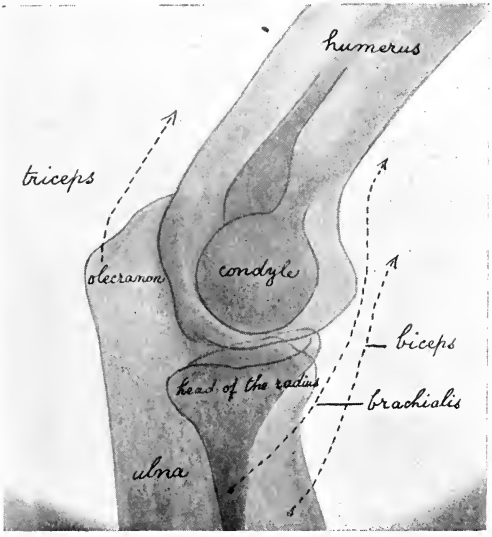
ARTICULATION OF THE SHOULDER.

Articulation of the shoulder or scapulo-humeral (radiograph): posterior view.

PLATE XXXVIII.



Radiograph: anterior view.



Radiograph: lateral view.

ARTICULATION OF THE ELBOW.

Articulation of the Elbow.

(*Plate XXXVIII.*)

Surfaces.—The elbow constitutes a triple articulation: humero-ulnar, humero-radial, and proximal radio-ulnar. The *humerus* furnishes medially *the trochlea*, a pulley in an antero-posterior groove, articulated with the ulna; laterally the *condyle*, a rounded projection articulated with the radius; and above and at the side of these surfaces, two important extra-articular projections: the *medial epicondyle* and the *lateral epicondyle*, from which numerous muscles of the fore-arm arise.

The proximal extremity of the *ulna* is formed by two bony masses: the *olecranon* and the *coronoid process*, between which the *semilunar notch*, adapted to the humeral trochlea, opens in front. The *head of the radius* presents a shallow cup on its proximal aspect, with which the capitulum of the humerus articulates, and the rounded border of the cup rolls in the small radial notch situated on the lateral aspect of the coronoid process of the ulna.

Ligaments.—The *ligaments* are constituted by a very tough fibrous capsule, the insertion of which borders upon the articular surfaces, and is strengthened by powerful anterior, posterior, medial, and lateral fasciculi; this capsule envelops and maintains all three articulations; a single *synovial membrane* covers the internal aspect of this capsule, and sends an important posterior extension below the tendon of the triceps.

Round the articulation are *numerous muscles:* in front, the brachialis and the tendon of the biceps; behind, the triceps; laterally, the brachio-radialis and the radial extensors; medially, the epicondylic muscles—viz., pronator teres, flexor carpi radialis, flexor carpi ulnaris, and flexors of the fingers.

Important Connexions : in front, the brachial artery and the median nerve; behind and medially (ulnar groove), the ulnar nerve.

Movements.—Angle of flexion, 45°; extension, 185°; amplitude of movement, 140°.

No lateral movements.

Radio-ulnar Articulations.

(*Plates XXXVIII. and XXXIX.*)

Surfaces.—The two bones of the forearm are united above by the *proximal radio-ulnar* articulation, which forms part of the elbow; below, by the *distal radio-ulnar* articulation, which forms part of the wrist; and in the intervening space by a broad interosseous ligament.

In the proximal articulation, the border of the head of the radius turns in the small radial notch of the ulna; the surfaces are maintained in contact by the annular ligament, which tightly encloses the neck of the radius, and is attached to the borders of the notch.

In the *distal radio-ulnar articulation* the lateral convex aspect of the head of the ulna turns in the ulnar notch on the medial side of the distal end of the radius. The synovial membrane of this articulation is sometimes independent, sometimes attached to that of the wrist.

Means of Union.—A fibrous capsule and a triangular fibro-cartilaginous ligament which attaches the styloid process of the ulna to the line of demarcation between the ulnar notch and the carpal articular surface of the radius.

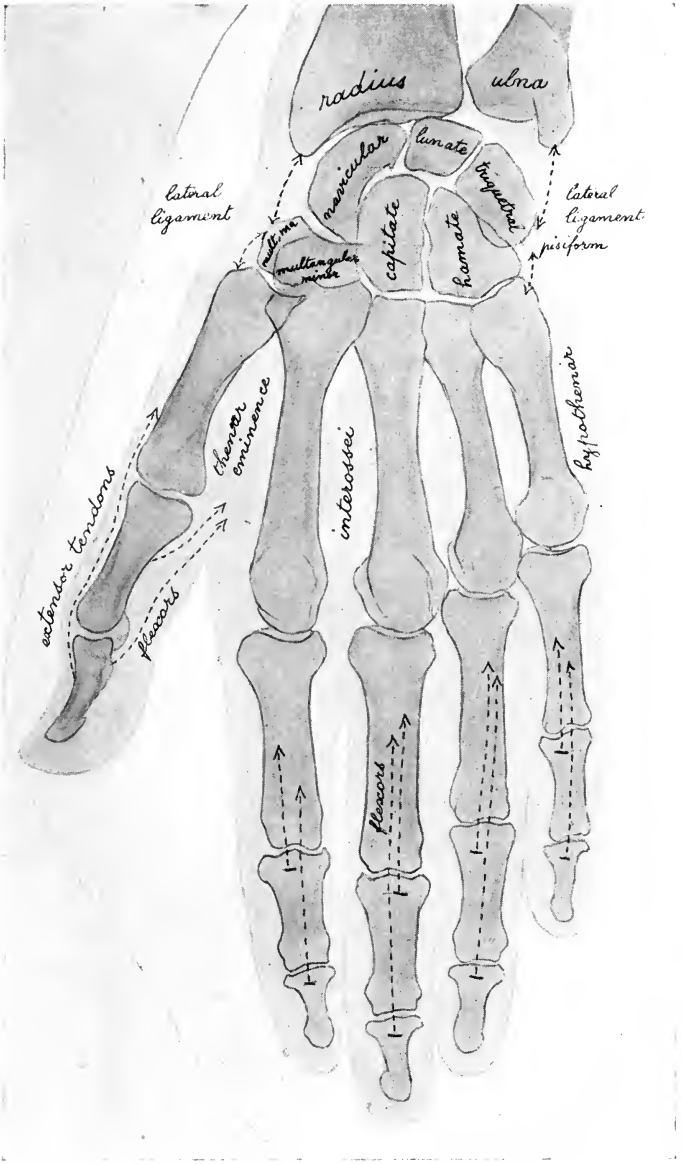
Movements.—Rotation, pronation, or supination, according to the position of the hand. Under the action of the muscles pronator teres and pronator quadratus, brachio-radialis and supinator, biceps and anconeus, the radius turns on the ulna, which remains stationary; the normal maximum movement is about 170°.

Articulation of the Wrist.

(*Plates XXXIX., XL., and XLII.*)

Surfaces.—A very supple enarthrosis which unites the distal extremities of the ulna and the radius to the first row of carpal bones (navicular, lunate, and triquetral); the bones of the carpus form a condyle which fits into a glenoid cavity, three-quarters of which is constituted by the radial epiphysis, and is completed on the medial side by the triangular fibro-cartilaginous ligament of the distal radio-ulnar articulation.

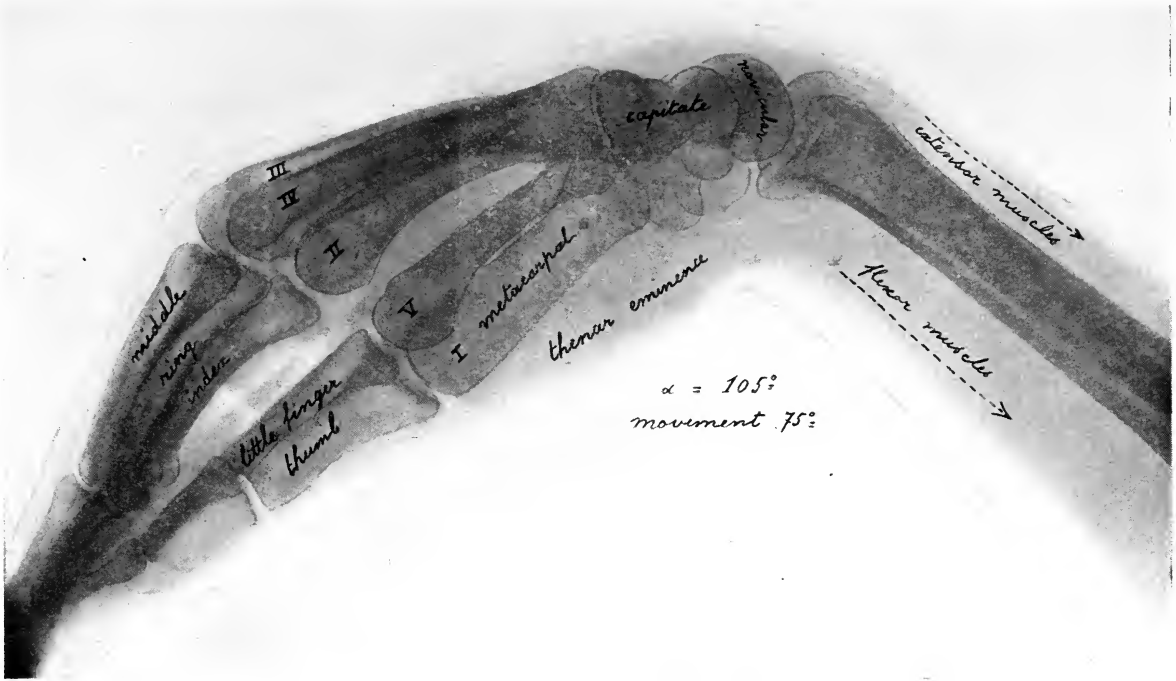
PLATE XXXIX.



ARTICULATIONS OF THE WRIST AND HAND.

Radiograph of the wrist and hand: palmar aspect.

PLATE XL.



Articulations of the Wrist and Hand in Profile and in Extension.

Synovial Membrane.—Very loose, communicating in most cases with the synovial membranes of the neighbouring articulations (radio-ulnar and intercarpal).

Means of Union.—A thick and tough capsule, especially in front, strengthened by numerous anterior, posterior, medial, and lateral fibrous fasciculi, attached to the projections of various bones of the carpus. The lateral and medial ligaments are particularly strong.

The *intervening space* is marked out by the radial and ulnar styloid processes. The articulation is surrounded by the tendons of the muscles of the hand, furnished with synovial sheaths: in front, the flexor muscles and palmar muscle gliding in the carpal groove; behind, the extensors maintained by the dorsal ligaments of the carpus; laterally, the radial extensors and the abductor of the thumb; medially, the flexor carpi ulnaris.

Movements.—The carpal condyle rolls on the antibrachial glenoid cavity, laterally (adduction and abduction of the hand) and in the antero-posterior direction (flexion and extension); angle of adduction, 130° to 140°; angle of abduction, 150° to 160°; amplitude of movement, 60° to 70°; angle of flexion, 80° to 90°; angle of extension, 40° to 50°; amplitude of movement, 120° to 130°.

Intercarpal and Intermetacarpal Articulations.

(*Plates XXXIX., XL., and XLI.*)

The various bones of the carpus articulate with each other by many small surfaces, of which the whole resembles a mosaic when seen in section.

Anatomically and mechanically, these bones are distributed into two groups: *the proximal group, i.e.* the first row (navicular, lunate, and triquetral bones) forms a crescent, of which the convexity constitutes the condyle of the radio-carpal articulation, and the distal concavity serves as a glenoid fossa for the second row. In this first group, the lunate bone, situated in the middle, articulates laterally with the navicular, and medially with the triquetral bone. The pisiform, inde-

pendent and in an anterior plane, articulates with the triquetral bone.

The *distal group*, which consists of the greater and the lesser multangular, the capitate and hamate bones, is stretched more widely, and forms, especially with the last two, a very accentuated projection which penetrates into the concavity of the proximal row. Below, it articulates with the bases of the five metacarpal bones: the greater multangular with the first and second, the lesser multangular with the second, the capitate with the second and third, the hamate with the fourth and fifth.

The *metacarpal bases* articulate with each other laterally by small, nearly flat surfaces.

A single *synovial membrane*, but one with many partitions and diverticula, serves for all these intercarpal, carpometacarpal, and intermetacarpal articulations, except for that of the greater multangular and first metacarpal bone, which is independent.

Closely supported by interosseous ligaments and numerous fibrous capsular fasciculi, anterior, posterior, medial, and lateral, these articulations are the seat of gliding movements of little extent, but the combination of which allows of very supple and powerful play for the various movements of the hand and fingers, especially those of prehension and rotation.

Articulations of the Fingers.

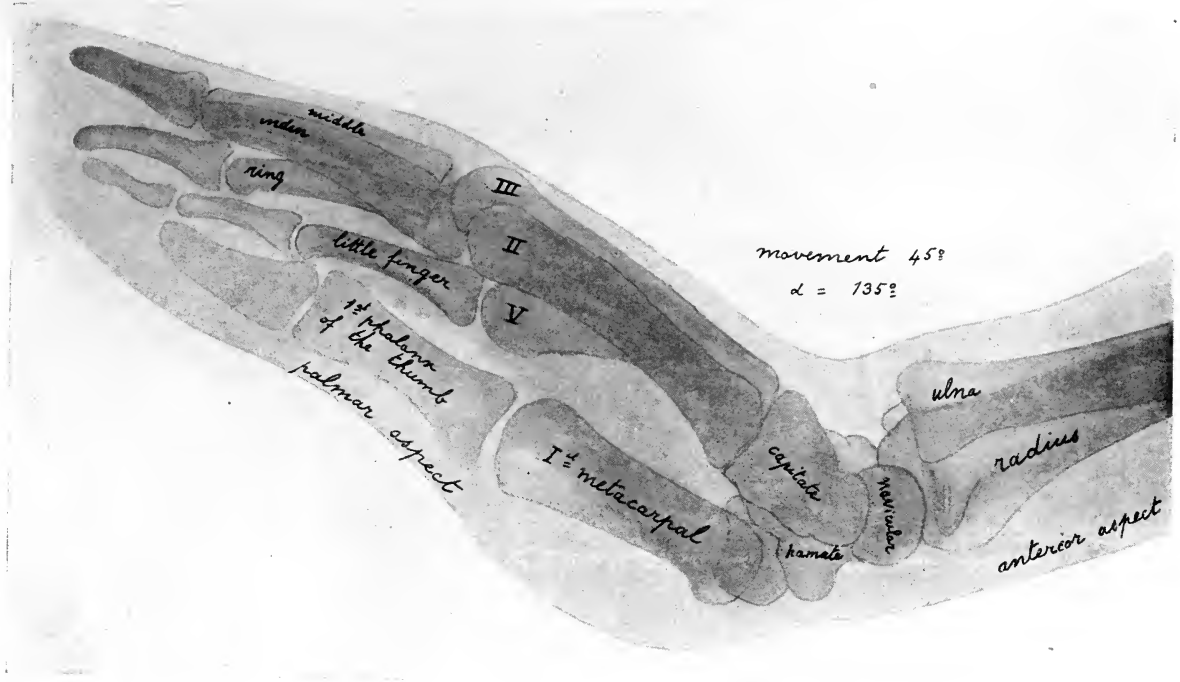
(*Plates XXXIX. to XLII.*)

(1.) Metacarpo-phalangeal Joints.

Surfaces.—For each finger, the rounded head of the metacarpal bone articulates with the hollowed base of the first phalanx.

A *fibro-cartilage*, crescent-shaped, enlarges the phalangeal glenoid cavity on the palmar side. A *capsule*, very loose, especially in front, is strengthened by lateral ligaments and by extensor, flexor, interosseous, and lumbrical tendons. Some constant *sesamoid bones* in the thumb, the index and little finger, adhere to the palmar surface of the capsule.

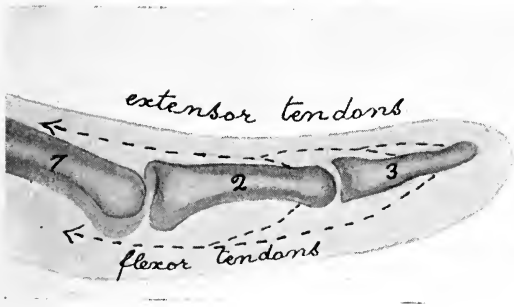
A relatively large and supple *synovial membrane*.



ARTICULATIONS OF THE WRIST AND HAND.
In Profile and Forced Extension.

PLATE XLII.

Articulations of the Fingers.



Finger in extension.

Finger in flexion.

Movements.—Flexion and extension, 85° to 90°; abduction and adduction, 30° to 40°. Slight movements of rotation.

The *thumb* has very extensive movements, which occur especially at the multangulo-metacarpal joint. The first metacarpal has the same action as a first phalanx. Adduction or abduction (metacarpal), 50° to 60°. The opposition of the thumb, or adduction, in the anterior planes, has nearly the same amplitude. The flexion of the first phalanx on the metacarpal bone is only from 60° to 65°.

(2.) Intermetacarpal Joints.

Surfaces.—The distal extremity or head of the phalanx above, in the form of a trochlea or double condyle, fits into the base of the phalanx below, which is in the form of a double glenoid cavity.

Synovial membrane, capsule, lateral ligaments, extensor and flexor tendons, are placed somewhat in the same manner as for the metacarpo-phalangeal joints. To the last but one phalanx is inserted the superficial flexor; to the last, the extensor and the deep flexor; to the proximal, the interossei.

Movements.—Flexion, extension, second phalanx, 110° to 120°; third phalanx, 60° to 70°. Very slight lateral and rotatory movements. Flexion of the second phalanx of the thumb, 70° to 75°.

The *movements of the fingers* are effected by *long muscles* (extensors, flexors, abductors) which come from the forearm, and *short muscles* which come from the carpal and metacarpal bones (thenar, hypothenar, interosseous); by the muscles *common* to them, which act upon the greater number of the fingers (extensors, flexors), and the muscles *proper* to them, which act only on individual fingers. The lateral and medial fingers are particularly well provided. The *thumb*, supplied with the muscles of the thenar eminence, has a long and a short flexor of its own, a long and a short extensor, a long and a short abductor, an adductor, an opponens, and an interosseous.

The *little finger* is supplied with two long flexors, a long extensor proper, two interosseous and by the muscles of the hypothenar eminence: short flexor, abductor, and opponens.

The *intermediate fingers* are acted upon by a long common extensor, two long common flexors, and two interosseous which regulate the movements of abduction and adduction. The *index finger* is also provided with a long extensor proper.

Articulation of the Hip.

(*Plate XLIII.*)

Surfaces.—*Cotyloid cavity of the iliac bone* at its lateral portion and at the point of union of the three segments of this bone: ilium, ischium, and pubis; nearly hemispherical, with a cartilaginous covering in the form of a crescent, leaving a non-articular median zone where the *teres ligament* is inserted. A *fibro-cartilaginous triangular pad* increases its area.

Head of the femur, almost spherical, with a smooth cartilaginous surface, except in the neighbourhood of its apex, where the other extremity of the *teres ligament* is attached.

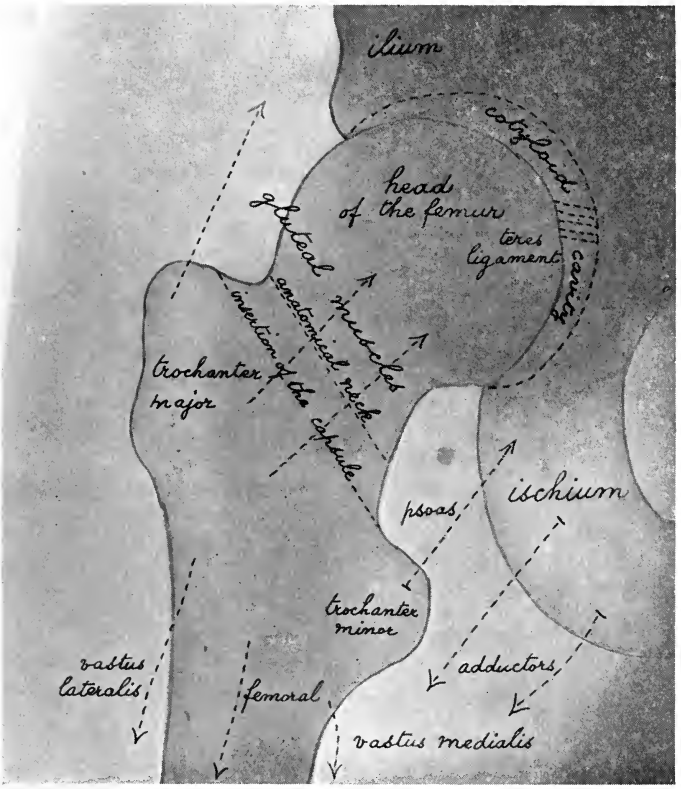
Means of Union.—The two bones are bound by this *teres ligament*, a thick and short fibrous ribbon encased in fat, which limits more especially the movement of flexion; and by the *capsule*, which adheres above to the glenoid pad, and is attached very low down to the limits of the neck of the femur, near the two trochanters. Important ligaments (ilio-, ischio-, and pubo-femoral) strengthen this capsule. The whole constitutes a most unyielding fibrous muff.

A very extensive *synovial membrane* covers the greater portion of the internal surface of the capsule, and surrounds the teres ligament in the articular space. Numerous *muscles* envelop the articulation: in front, the psoas, the gracilis, the pectineus, which are in contact with the capsule; behind and laterally, the glutæus maximus and glutæus medius; medially, the obturator externus, the pyramidalis, and the hamstrings.

Important Connexions : in front and medially: the femoral artery and femoral nerve; behind and medially, the sciatic nerve.

Movements.—Flexion in front on the pelvis, 80° to 90°; forced extension backwards, 40°; total, 120° to 130°. Abduction, 50° to 55°; adduction, 50° to 55°; total, 100° to 110° (measurements taken with the thigh extended from the trunk). The flexion of the thigh on the pelvis is due chiefly to the ilio-

PLATE XLIII.



ARTICULATION OF THE HIP.

Articulation of the hip or coxo-femoral (radiograph): antero-posterior.

psoas muscle, but also to the muscles rectus femoris, tensor fasciæ latæ, sartorius, pectineus, and adductor longus.

Extension is due chiefly to the gluteal muscles, but also to the biceps, semitendinosus, and semimembranosus.

Adduction to the obturator muscles, the pyramidalis, the pectineus, and especially to the adductors and the gracilis; abduction to the glutei and the tensor fasciæ latæ.

Articulation of the Knee, or Femoro-tibial.

(*Plates XLIV., XLV., and XLVI.*)

Surfaces.—At *the distal extremity of the femur there are two large condyles*, medial and lateral, united in front by a groove or trochlea in which the patella glides, and separated behind by the deep intercondyloid notch, where the popliteal vessels and nerves and the cruciate ligaments are situated.

At the *proximal extremity of the tibia there are two glenoid surfaces*, slightly hollowed, on which the condyles roll, separated by two small middle projections (spines of the tibia), their border raised by two semilunar cartilages. In front of the femoral trochlea, the posterior aspect of the patella is divided by a middle crest into two slopes which are opposite to the two condyles. All these surfaces are covered with a thick layer of cartilage.

Means of Union.—They are united by a very compact complex ligamentous system, which comprises:

A *capsule*, enveloping the three bones, fixed some distance beyond the articular surfaces, and adhering to the fibro-cartilages, to the cruciate ligaments, and to the patellar tendon. Thick and unyielding, this capsule forms two fibrous shells round the condyles, and is strengthened by medial, lateral, and posterior ligaments.

The *cruciate ligaments*, interosseous, are attached high up in the intercondyloid notch, and below, after crossing, between the glenoid surfaces of the intercondyloid tubercles of the tibia.

The *ligamentum patellæ* binds the inferior border of the patella to the tuberosity at the proximal end of the tibia, and the medial and lateral patellar ligaments bind the sides of the

patella to the corresponding sides of the condyles. In front there are the *muscles:* quadriceps, biceps, and lateral portion of the gastrocnemius outside; sartorius, semitendinosus, and medial portion of the gastrocnemius inside; and behind, all are enclosed in a strong femoral aponeurosis, and contribute to maintain in close apposition the articular surfaces of the knee, near which they are inserted.

A *large synovial membrane* clothes the deep aspect of the capsule, and is prolonged by important blind alleys beyond the articular surfaces, in particular above the patella under the tendon of the quadriceps, and in the popliteal space, to above the condyles.

In addition, a *large mass of adipose tissue* occupies the free space behind the patellar ligament, and penetrates into the intervening space, outside the synovial membrane, to the borders of the cruciate ligaments. A great quantity of fat in the same way covers the floor of the popliteal space, enveloping the vasculo-nervous organs which cross it.

Movements.—No lateral movement. The articulation is organised strictly in view of the statics, and only allows of antero-posterior movements of flexion and extension necessary for walking. Angle of maximum measurement, 180°; angle of flexion, 45°; amplitude of movement, 135°.

Extension is due to the quadriceps; flexion to the biceps, sartorius, semitendinosus, semimembranosus, and gracilis.

Tibio-fibular Articulations.

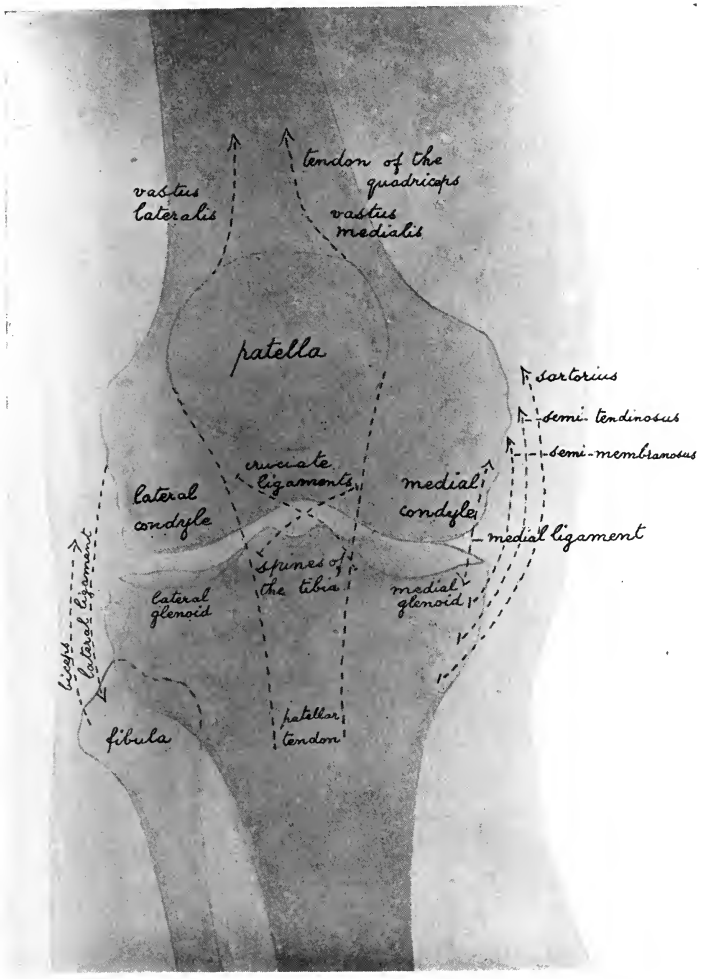
(*Plate XLIX.*)

The fibula and the tibia are united at their extremities by small articular surfaces and strong ligaments which only allow of slight stretching or gliding movements.

The synovial membrane of the proximal articulation is independent; that of the distal articulation is an offshoot of the tibio-tarsal synovial membrane.

The distal articulation is more mobile than the proximal, and participates to an important extent in the suppleness of the foot in walking. Between the two articulations, an interosseous ligament binds the fibula to the tibia, and gives insertion to the anterior and posterior muscles of the leg.

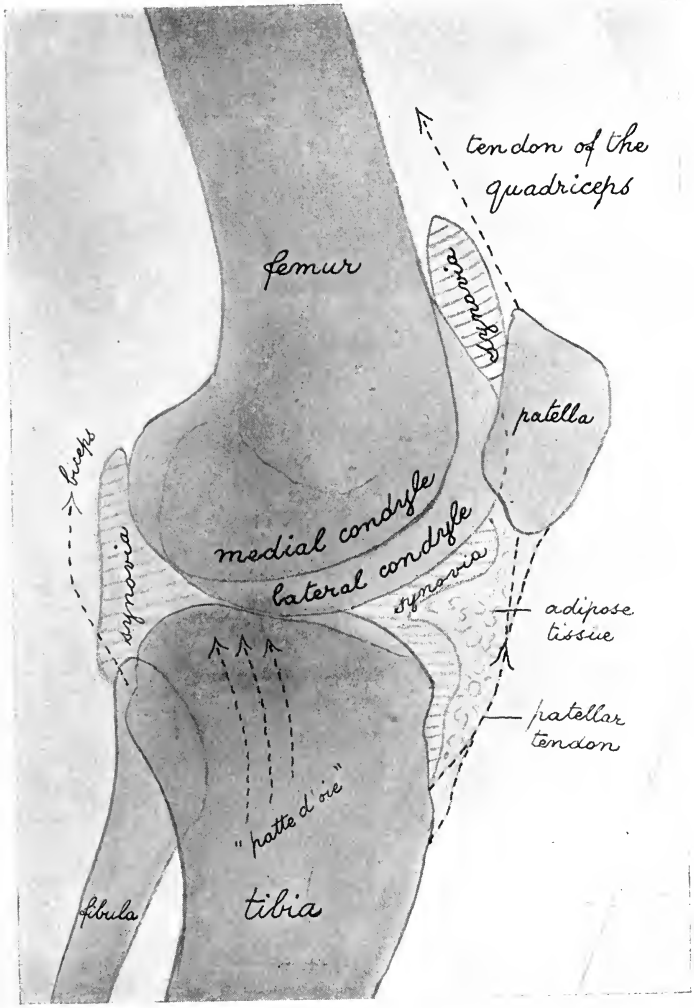
PLATE XLIV.



ARTICULATION OF THE KNEE.

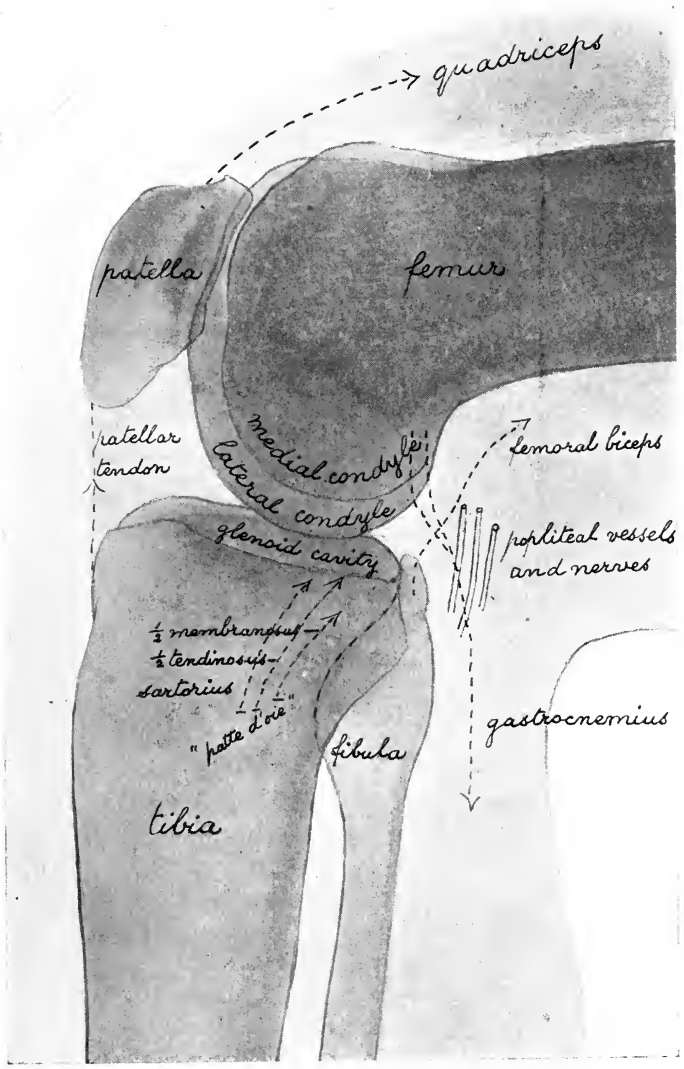
Articulation of the knee in extension (radiograph): anterior view.

PLATE XLV.



ARTICULATION OF THE KNEE.

Articulation of the knee: medial aspect. Radiograph of the knee in profile and in extension.



ARTICULATION OF THE KNEE.

Articulation of the knee: medial aspect. Radiograph of the knee in profile and in flexion.

Articulation of the Ankle, or Talo-cruralis.

(*Plates XLVII., XLIX., L., and LI.*)

Surfaces.—The *distal extremities of the tibia and fibula,* closely united, form with their malleoli (the lateral lower than the medial) a transverse and antero-posterior mortise with a double concavity.

The *postero-superior portion of the talus* constitutes a bolt exactly adapted to the tibio-fibular mortise, with a superior surface regularly convex in the antero-posterior direction, and with two medial and lateral aspects with blunt corners, and with inclined planes which fit the two malleoli.

Means of Union.—A *fibrous muff* is attached to the circumference of the articulation, thick, tight, and very tough at the sides, where it is strengthened by powerful medial and lateral ligaments which are looser in front and behind.

The *synovial membrane,* particularly extensive in front and behind, communicates with the tibio-fibular synovia.

Movements.—Flexion and extension of the foot on the leg by antero-posterior rotation of the talus in the tibio-fibular mortise.

Angle of flexion, 95°; angle of extension, 160°; amplitude of movement, 65°.

Adduction and abduction of the foot by transverse rotation of the talus, completed by the play of the infrataloid articulations.

Angle of adduction, 130°; angle of abduction, 165°; total movement, 65°.

The flexion of the foot is due to the tibialis anterior and the extensors of the toes. Extension to the muscles of the tendo Achillis (gastrocnemius and soleus) and to the long flexors of the toes. Abduction to the peronei. Adduction to the tibialis anterior and tibialis posterior, and to the flexors of the toes.

Talo-calcaneo-navicular Articulation.

(*Plates XLIX., L., and LI.*)

It unites the talus to the calcaneus and to the navicular bone, and comprises an anterior and a posterior portion, separated by a deep transverse groove, on the talus and calcaneus, in which an interosseous ligament is inserted.

Behind, on an almost horizontal plane, a slightly hollowed surface on the talus rests on a slightly convex surface of the calcaneus.

In front, the rounded head of the talus articulates with a glenoid cavity formed by the superior surface of the anterior extremity of the calcaneous and the superior surface of the naviculus.

On the cirumference of these surfaces a capsule is inserted for the anterior articulation and one for the posterior.

Between the two is the interosseous talo-calcaneal ligament, a very strong lamina which occupies all the groove or sinus of the tarsus. There is a distinct synovial membrane for each articulation, the posterior communicating most frequently with the talo-cruralar synovia.

Movements.—They are limited: antero-posterior contributing to the flexion of the foot, and transverse ones contributing to the movements of adduction and abduction, with internal and external rotation of the foot.

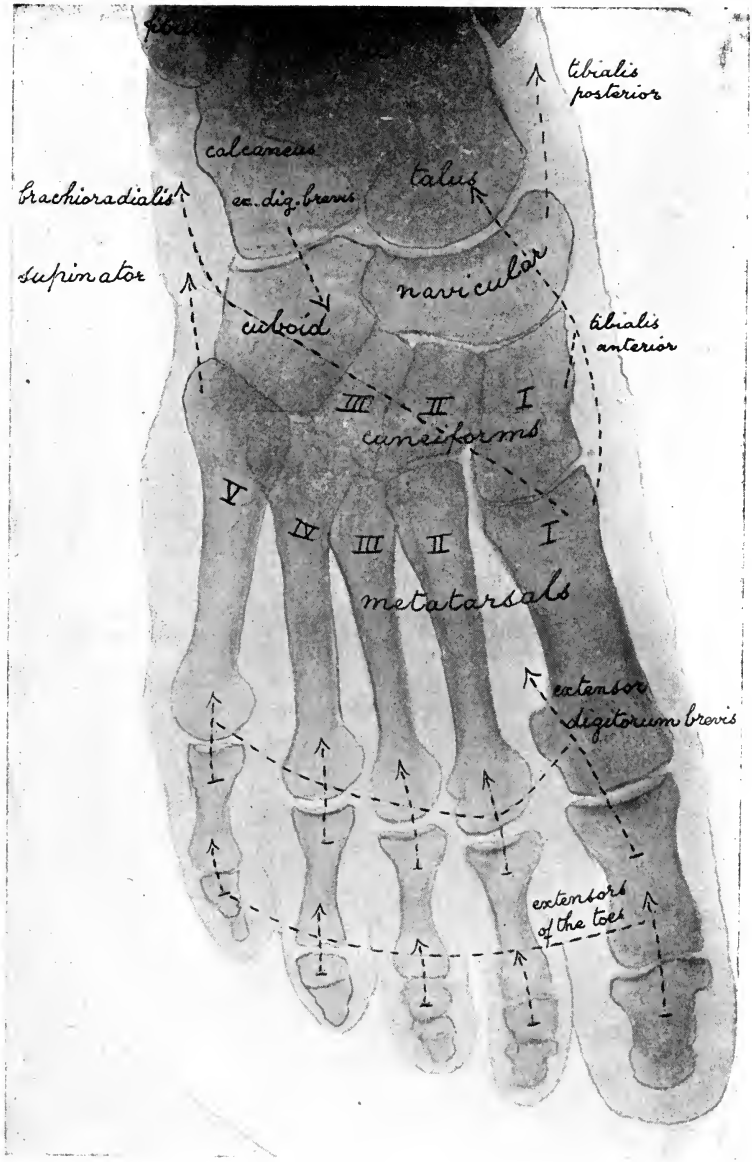
Calcaneo-cuboid Articulation.

(*Plates XLVII. to LI.*)

On the *anterior portion of the calcaneus* there is an articular surface, convex transversely, and concave from top to bottom; on the *posterior portion of the cuboid* there is a surface with inverse curves, which fits the articular surface of the calcaneus. These surfaces are kept in apposition by a *capsule*, by a strong **V**-*shaped ligament* (*Chopart's ligament*) which goes from the calcaneus to the cuboid and to the naviculus, and by a broad *inferior ligament* which binds the inferior surfaces of the calcaneus, the cuboid, and the third, fourth, and fifth metatarsal bones. The two articulations, talo-navicular and calcaneo-cuboid, anatomically very distinct, are, from a surgical point of view, united under the name of *Chopart's articulation*, the line of which joins the medial border of the foot at the tubercle of the naviculus.

From a mechanical point of view these two articulations form, with the infratalar joint, an important whole for the movements of medial or lateral torsion of the foot, as well as for walking and for the upright position.

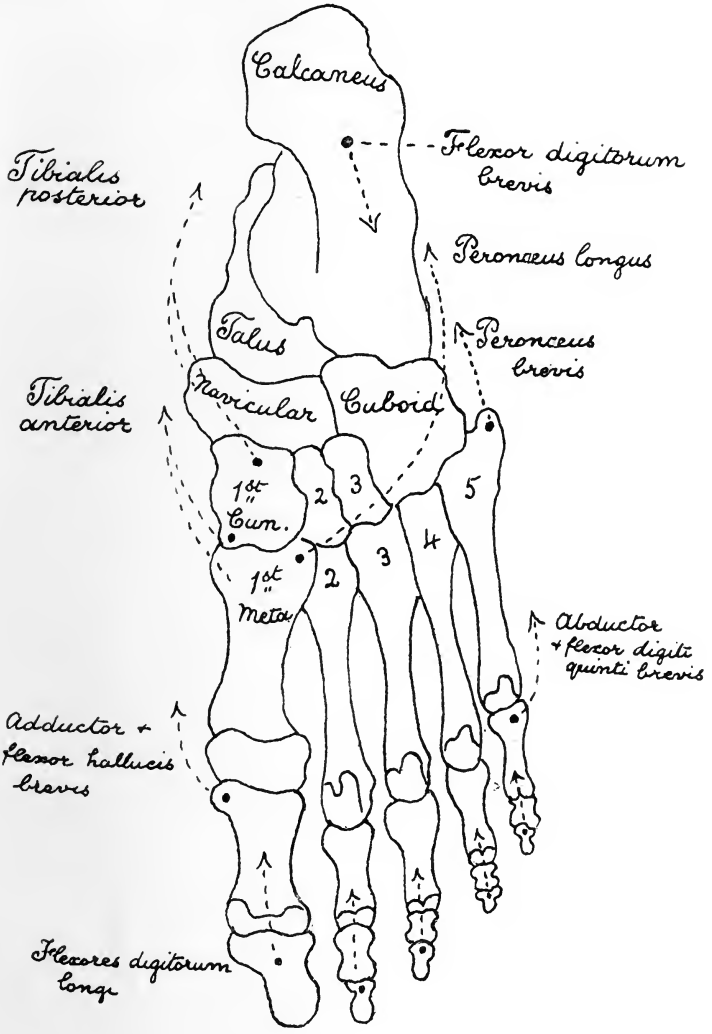
PLATE XLVII.



ARTICULATIONS OF THE FOOT.

Radiograph of the articulations of the foot: dorsal aspect.

PLATE XLVIII.



ARTICULATIONS OF THE FOOT: PLANTAR ASPECT.

Articulations of the Anterior Tarsus.

(*Plates XLVII. to LI.*)

The *naviculus* and the *cuboid* articulate by two small lateral facets, united by superior and inferior interosseous ligaments.

The *three cuneiforms* articulate with each other and with the medial aspect of the cuboid much in the same way. The inclination of the lateral aspects of these three bones makes them converge towards the plantar aspect of the second cuneiform, which corresponds with the vertical axis of the upper limb in a standing position.

Thus united, the *cuneiforms* articulate by their posterior aspect with the anterior aspect of the naviculus, on which are to be seen three corresponding articular facets.

A synovial membrane is common to this last articulation and to the intercuneiform articulations. A capsule, likewise common, is strengthened by dorsal, plantar, and medial ligaments.

In front, the cuneiforms articulate with the corresponding metatarsal bones one, two, and three, and the cuboid with four and five. The whole of these tarso-metatarsal articulations constitute *Lisfranc's intervening space*, which is indicated on the middle of the lateral border of the foot by the tubercle of the fifth metatarsal bone.

Intermetatarsal Articulations.

(*Plates XLVII., XLVIII., and XLIX.*)

Behind, the metatarsal bones are in contact with each other on their medial and lateral aspects. Contact is maintained by the interosseous, dorsal, and plantar ligaments. The synovial membranes of Lisfranc's intervening space send continuations into these small joints. In front, the heads of the metatarsal bones are not in articular contact, but simply bound by a transverse dorsal ligament.

Metatarso-phalangeal Articulations.

(*Plates XLVII. and XLVIII.*)

In the toes, as in the fingers, the somewhat regularly rounded head of the metatarsal bones rolls in a glenoid cavity formed by the proximal extremity of the first phalanx. There is a capsule for each toe, strengthened by a fibro-cartilaginous plantar pad and by lateral and medial ligaments.

In the *great toe*, the articulation is particularly well developed, serving as an important point of support in walking. Two plantar *sesamoid bones* adhere to the capsule and the fibro-cartilage.

The *interphalangeal articulations* of the toes are analogous to those of the fingers, but little developed. The second and third phalanges are of very small dimensions and of little use to man.

Movements.—The movements of the metatarsal bones on the tarsus are limited to slight gliding in different directions.

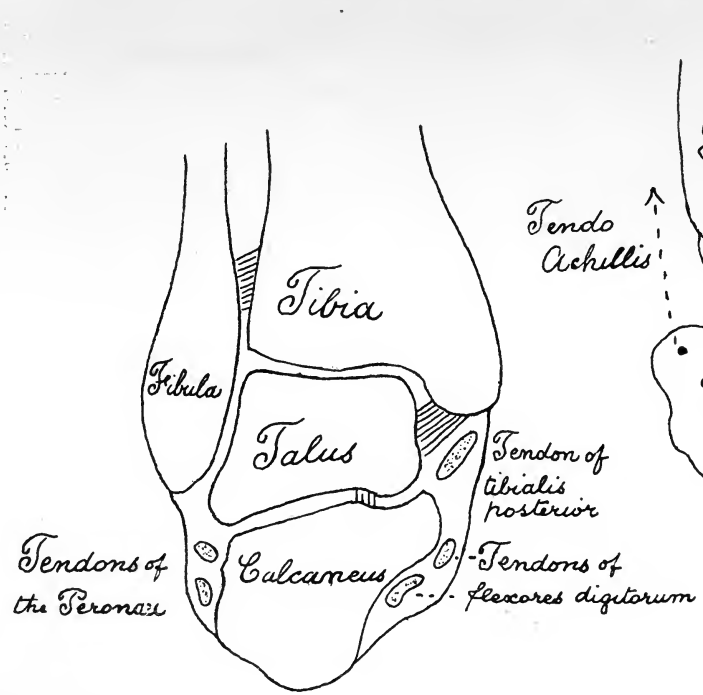
The toes have movements of flexion and extension, which are relatively extensive on the metatarsals, produced by the flexor and extensor muscles, and movements of separation, specially marked for the first and fifth toes, which are due to the interosseous muscles.

The second phalanges have on the first, and the third phalanges have on the second, slight movements of flexion and extension due to the lumbricales and the interossei.

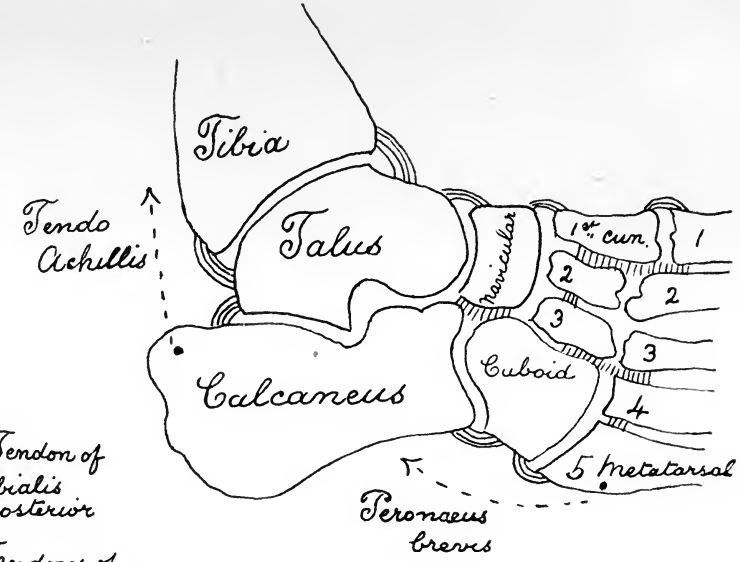
The rôle of these various articulations of the metatarsus and the toes is to allow of considerable distribution of force, which renders walking more free and diminishes the fatigue of the upright position. From this point of view, the form of the plantar arch is particularly important. On account of the disposition of the articular surfaces, this arch is supported during a standing position by the action of the peronæus longus, tibialis anterior, tibialis posterior, flexor digitorum longus, and flexor digitorum brevis.

PLATE XLIX.

ARTICULATIONS OF THE FOOT. (Scheme in part after Testut.)

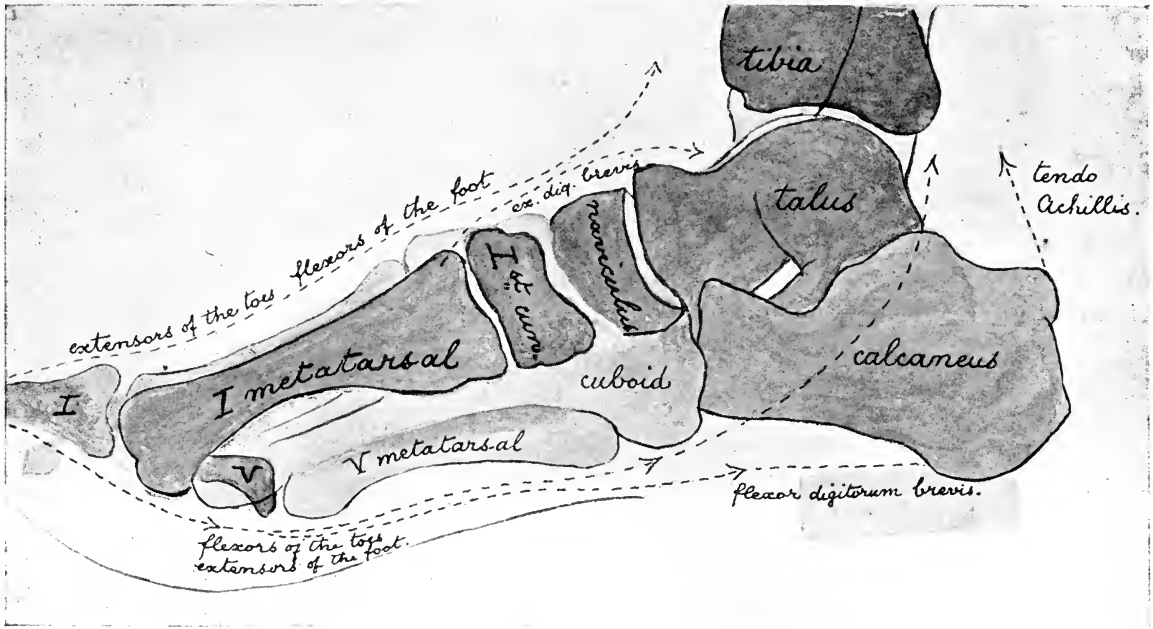


Transverse sections through the middle of the talo-cruralar and infratalar articulations.



Tarsal and tarso-metatarsal articulations.

PLATE L.



RADIOGRAPH OF THE FOOT IN PROFILE IN HALF-FLEXION: MEDIAL ASPECT.

NORMAL AVERAGE AMPLITUDE OF THE PRINCIPAL ACTIVE MOVEMENTS

Head.—Combined movements of the head on the neck and of the neck on the thorax.

Point of departure for measurement: head erect, looking forwards.

Auriculo-nasal line horizontal.

Anterior flexion: 35°.

Posterior flexion or extension: 40°.

Total antero-posterior movement: 75°.

Lateral inclination: 30° on each side.

Total movement: 60°.

Horizontal rotation: 70° on each side.

Total movement: 140°.

Shoulder.—Combined movements of scapulo-humeral and scapulo-thoracic articulations.

Abduction and lateral elevation of the arm: total movement, 150°.

100° for rotation of the humerus on the scapula (deltoid).

50° for rotation of the scapula on the thorax (trapezius and serratus anterior).

The two movements are made simultaneously, and nearly in the following relations:

Departure: low vertical position of the hand.

	Movement of the Humerus on the Scapula.	Movement of the Scapula on the Thorax.
First time: arm at 45°	30°	15°
Second time: arm horizontal at 90°.. ..	35°	10°
Third time: arm raised to the maximum, 150°	35°	25°
	100°	50°

Antero-posterior vertical rotation of the arm: 160° in front, 40° behind; total, 200°.

Antero-posterior horizontal rotation of the arm on a level with the shoulder: 110° in front, 15° behind; total, 125°.

Circumduction: above movements combined in different planes at a maximum average angle of 140° to 150°.

Torsion or longitudinal rotation of the arm : about 80°.

Elbow.—Extension and flexion : no lateral movement.

Angle of flexion: maximum, 45°; angle of extension, 180°; movement, 135°.

Radio-ulnar Articulations.—Pronation and supination; total movement, 170°.

The movement is completed in both directions to about 260° by longitudinal rotation of the arm.

Wrist.—Point of departure: the hand in a line with the forearm.

Extension, 45°; **flexion,** 80°; total movement, 125°.

Abduction, 20°; **adduction,** 40°; total lateral movement, 60°.

Fingers.—Flexion :

	First Phalanx on the Metacarpal.	Second Phalanx on the First.	Third Phalanx on the Second.
Second, third, fourth, and fifth fingers	85°	110°	75°
Thumb	70°	85°	—

Spreading or abduction of the fingers: second, third, fourth fingers, 40°; thumb, 70°; little finger, 50°.

Hip.—Departure: the thigh in the axis of the trunk (vertical position or supine).

Flexion of the thigh on the pelvis, 80° to 90° } total, 120°
Extension forced backwards, 40° } to 130°.

Abduction, 55°; **adduction,** 54°; total, 110°.

Circumduction : above movements combined in different planes and at an average maximum angle of 110°.

Knee.—Angle of **extension,** 180° }
Angle of **flexion,** 45° } movement, 135°.

No lateral movement.

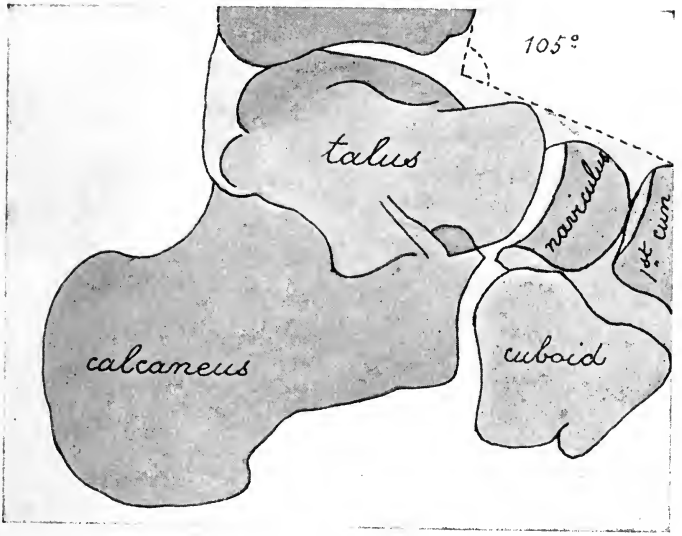
Foot.—Combined movements of tibio-tarsal and intertarsal articulations.

Angle of **extension,** 160°; angle of **flexion,** 95°; movement, 65°.

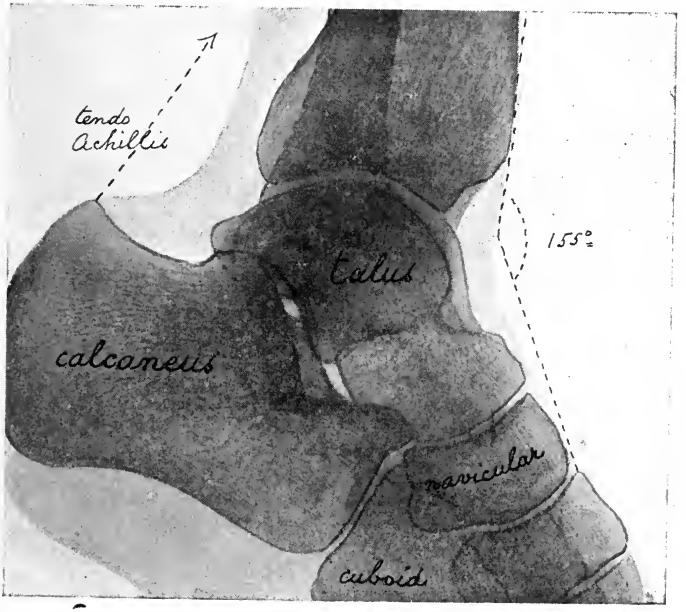
Angle of **adduction,** 130°; angle of **abduction,** 165°; movement, 65°.

PLATE LI.

Radiograph of the Ankle.



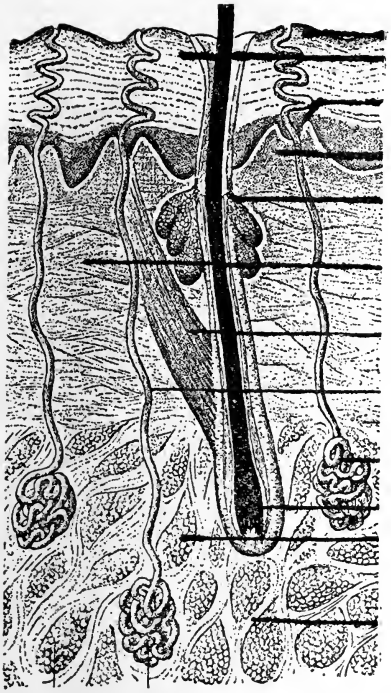
Radiograph of the ankle in flexion: tibio-tarsal, infratalar, and transverse tarsal joints.



Radiograph of the ankle in extension: tibio-tarsal, infratalar, and transverse tarsal joints.

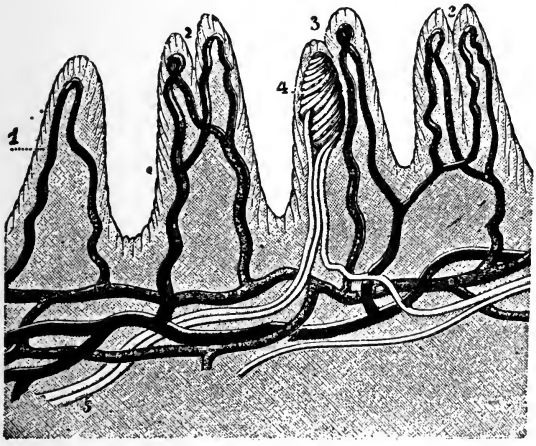
PLATE LII.

Skin.



Horny layer of the epidermis.
Mucous layer of the epidermis.
Pigmentary layer of the epidermis.
Papillæ of the corium.
Sebaceous gland.
Connective tissue of the corium.
Arrector muscle of the hair.
Excretory canal of sweat gland.
Sweat gland.
Hair follicle.
Panicle of adipose tissue.
Subcutaneous adipose cellular tissue.

Section of the Skin. (After Testut.)



Papillæ of the corium with their vessels and a touch corpuscle (4).

IX.—THE SKIN.

(*Plate LII.*)

The skin, which forms a general covering for the body, and is the seat of the sense of touch, is composed of the corium and the epidermis, and is lined with a layer of cellular adipose tissue very richly supplied with nerves and blood-vessels. Being exposed to the elements, it has a very important and complex part to play of protection, perception, and absorption.

The *epidermis*, the average thickness of which is $\frac{1}{10}$ to $\frac{1}{4}$ millimetre, is formed by a superficial horny layer (stratum corneum), which acts as a protecting coat, and a mucous layer of polyhedric cells, at the base of which there is a row of cylindrical cells filled with a brown or black pigment. This *pigment*, more or less marked according to race, is developed and becomes more black under the action of the chemical rays of light. It appears to be protective, but its first effect is to absorb a great number of those radiations which, being of strong intensity, act upon the epidermis and provoke a more or less marked dermatitis (solar erythema).

The X rays also provoke the development of the pigment and of corio-epidermic lesions more or less grave.

The *corium*, the thickness of which varies from $\frac{1}{3}$ millimetre to 3 millimetres, is formed of a close web of connective tissue mixed with elastic fibres, and of smooth muscular fibres. It is united to the epidermis by a layer of papillæ which increase its surface for exchange, for absorption, and for radiation.

Its base, of looser tissue, intersected with fat, is continuous with the *subcutaneous cellular adipose tissue*, the thickness of which sometimes reaches 1 or 2 centimetres at certain points. This adipose tissue, a very bad conductor of obscure heat, protects the subjacent organs from chill; on the contrary,

it is relatively transparent for luminous rays. As they are bad conductors of electricity, adipose tissue, the corium, and the epidermis (especially the horny layer), oppose to the current a *resistance* which has been estimated at 200,000 ohms or more.

The corium and subcutaneous tissue contain the *hair follicles*, on which the X rays exercise a rapidly destructive selective action; the *sebaceous glands*, which secrete an oily matter (sebum); and *sweat glands*, which secrete the sweat.

A watery liquid, acid, saltish, slightly greasy, the sweat contributes to the elimination of certain substances, notably urea, toxins, and even bacteria, and in its evaporation performs a very important part in regulating heat.

The act of sweating, which is constant but feeble, is very much augmented by heat; it may give off from the whole body in one hour 800 grammes at 92·6 F. At that temperature 1 gramme of sweat uses up 580 microcalories in evaporation.

Abundantly provided with *nerve endings*, especially sensory, the skin presents *touch corpuscles* in the papillæ of the corium, in the hand and foot, and *Pacini's corpuscles* in the cellular adipose tissue over the whole surface of the body.

A rich network of bloodvessels and lymphatics insures an abundant circulation in the corium and the subcutaneous tissue. Regulated by vaso-motor nerves, this circulation is particularly sensitive to physical agents which, by causing a vaso-dilatation more or less prolonged, produce from the skin, under their immediate influence and almost in contact with the air, a great number of blood-corpuscles.

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